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SECTION 03101

FORMWORK FOR CONCRETE

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SECTION 03101

FORMWORK FOR CONCRETE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 347R	(1994) Guide to Formwork for Concrete

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 31	(1991) Making and Curing Concrete Test Specimens in the Field
ASTM C 39	(1986) Compressive Strength of Cylindrical Concrete Specimens
ASTM C 1074	(1987) Estimating Concrete Strength by the Maturity Method
ASTM C 1077	(1992) Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation

1.2 DESIGN

The design, engineering, and construction of the formwork shall be the responsibility of the Contractor. The formwork shall be designed for anticipated live, dead loads and lateral pressure and allowable stresses in accordance with Chapter 2 of ACI 347R. Form design shall comply with the tolerances specified in SECTION: CAST-IN-PLACE STRUCTURAL CONCRETE. The adequacy of formwork design and construction shall be monitored prior to and during concrete placement as part of the Contractor's approved Quality Control Plan.

1.3 SUBMITTALS

Government approval is required for all submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with SECTION 01330: SUBMITTAL PROCEDURES.

1.3.1 SD-01, Data

Materials; FIO.

Manufacturer's literature shall be submitted for plywood, concrete form hard board, form accessories, prefabricated forms, form coating.

1.3.2 SD-04, Drawings

Shop Drawings; GA.

Drawings and design computations for all formwork required shall be submitted at least 15 days either before fabrication on site or before delivery of prefabricated forms. The drawings and data submitted shall include the type, size, quantity and strength of all materials of which the forms are made, the plan for jointing of facing panels, detail affecting the appearance, and the assumed design values and loading conditions.

1.3.3 SD-09, Reports

Inspection; FIO.

The Contractor shall submit field inspection reports for concrete forms and embedded items.

Formwork Not Supporting Weight of Concrete; GA.

If forms are to be removed in less than 24 hours on formwork not supporting weight of concrete, the evaluation and results of the control cylinder tests or maturity instrumentation shall be submitted to and approved before the forms are removed.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Forms

Forms shall be fabricated with facing materials that will produce a finish meeting the specified construction tolerance requirements of SECTION: CAST-IN-PLACE STRUCTURAL CONCRETE.

2.1.1.1 Class "C" Finish

This class of finish shall apply to exposed concrete surfaces. The form facing may be either tongue-and-groove lumber, plywood, concrete form hard board or steel. Wood form facing for curved or warped surfaces shall be composed of splines of lumber which can be bent to the required shape without splitting or cracking to form a smooth tight form.

2.1.1.2 Class "D" Finish

This class of finish shall apply to faces receiving backfill. The form facing may be of wood or steel.

2.1.2 Form Coating

Form coating shall be commercial formulation of satisfactory and proven performance that will not bond with, stain, cause deterioration, or any other damage to concrete surfaces. The coating shall not impair subsequent treatment of concrete surfaces depending upon bond or adhesion nor impede the wetting of surfaces to be cured with water or curing compounds.

2.2 ACCESSORIES

Ties and other similar form accessories to be partially or wholly embedded in the concrete shall be of a commercially manufactured type. After the ends or end fasteners have been removed, the embedded portion of metal ties shall terminate not less than 2 inches from any concrete surface either exposed to view or exposed to water. Plastic snap ties may be used in locations where the surface will not be exposed to view. Form ties shall be constructed so that the ends or end fasteners can be removed without spalling the concrete.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Form Construction

Forms shall be constructed true to the structural design and required alignment. The form surface and joints shall be mortar tight and supported to achieve safe performance during construction, concrete placement, and form removal. The Contractor shall continuously monitor the alignment and stability of the forms during all phases to assure the finished product will meet the required surface or classes specified in paragraph: Construction Tolerances specified in SECTION: CAST-IN-PLACE STRUCTURAL CONCRETE. Failure of any supporting surface either due to surface texture, deflection or form collapse shall be the responsibility of the Contractor as will the replacement or correction of unsatisfactory surfaces. When forms for continuous surfaces are placed in successive units, care shall be taken to fit the forms over the completed surface to obtain accurate alignment of the surface and to prevent leakage of mortar. Forms shall not be re-used if there is any evidence of defects which would impair the quality of the resulting concrete surface. All surfaces of forms and embedded materials shall be cleaned of mortar from previous concreting and of all other foreign material before concrete is placed in them.

3.1.2 Chamfering

All exposed joints, edges and external corners shall be chamfered by molding placed in the forms unless the drawings specifically state that chamfering is to be omitted or as otherwise specified. Chamfered joints shall not be permitted where earth or rockfill is placed in contact with concrete surfaces. Chamfered joints shall be terminated 12 inches outside the limit of the earth or rockfill so that the end of the chamfers will be clearly visible.

3.1.3 Coating

Forms for exposed or painted surfaces shall be coated with form oil or a form-release agent before the form or reinforcement is placed in final position. The coating shall be used as recommended in the manufacturer's instructions.

Forms for unexposed surfaces may be wet with water in lieu of coating immediately before placing concrete, except that, in cold weather when freezing temperatures are anticipated, coating shall be mandatory. Surplus coating on form surfaces and coating on reinforcing steel and construction joints shall be removed before placing concrete.

3.2 FORM REMOVAL

Forms shall not be removed without approval of the Contracting Officer. The minimal time required for concrete to reach a strength adequate for removal of formwork without risking the safety of workers or the quality of the concrete depends on a number of factors including, but not limited to, ambient temperature, concrete lift heights, type and amount of concrete admixture, and type and amount of cementitious material in the concrete. It is the responsibility of the Contractor to consider all applicable factors and leave the forms in place until it is safe to remove them. In any case forms shall not be removed unless the minimum ambient temperature, and minimum compressive strength requirements below are met, or specifically authorized. When conditions are such as to justify the requirement, forms will be required to remain in place for a longer period. All removal shall be accomplished in a manner which will prevent damage to the concrete and ensure the complete safety of the structure. Where forms support more than one element, the forms shall not be removed until the form removal criteria are met by all supported elements. Evidence that concrete has gained sufficient strength to permit removal of forms shall be determined by tests on control cylinders. All control cylinders shall be stored in the structure or as near the structure as possible so they receive the same curing conditions and protection methods as given those portions of the structure they represent. Control cylinders shall be removed from the molds at an age of no more than 24 hours. All control cylinders shall be prepared and tested in accordance with ASTM C 31 and ASTM C 39 at the expense of the Contractor by an independent laboratory that complies with ASTM C 1077 and shall be tested within 4 hours after removal from the site. ASTM C 1074 procedures shall be used for estimating concrete strength by means of the maturity method. All expenses associated with evaluating the strength using maturity relationships shall be the responsibility of the Contractor.

3.2.1 Formwork Not Supporting Weight of Concrete

Formwork for walls, columns, sides of beams, gravity structures, and other vertical type forms not supporting the weight of concrete shall not be removed in less than 24 hours after concrete placement is completed. Form removal before 24 hours will be allowed for simple floor slab, sidewalks, and driveways provided the ambient temperature during this period has not fallen below 10 degrees C (50 degrees F) at any time since placement and evidence from compressive tests on field-cured concrete control cylinders indicates that the concrete has attained a compressive strength of at least 3.5 MPa (500 psi). Control cylinders shall be prepared for each set of forms to be removed before 24 hours. The stability of the concrete shall be evaluated by the Contracting Officer prior to removal of the forms.

3.2.2 Formwork Supporting Weight of Concrete

Supporting forms and shoring shall not be removed until structural members have acquired sufficient strength to safely support their own weight and any construction or other superimposed loads to which the supported concrete may be subjected. As a minimum, forms shall be left in place until control concrete test cylinders indicate evidence the concrete has attained at least 70 percent of the compressive strength required for the structure in accordance with the quality of mixture requirements of SECTION: CAST-IN-PLACE STRUCTURAL CONCRETE.

3.3 INSPECTION

Forms and embedded items shall be inspected in sufficient time prior to each concrete placement by the Contractor in order to certify to the Contracting Officer that they are ready to receive concrete. The results of each inspection shall be reported in writing.

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SECTION 03150

EXPANSION, CONTRACTION, CONSTRUCTION JOINTS, AND WATERSTOPS IN CONCRETE

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SECTION 03150

EXPANSION, CONTRACTION, CONSTRUCTION JOINTS, AND WATERSTOPS IN CONCRETE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 1751	(1983; R 1991) Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D 1752	(1984; R 1992) Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D 2628	(1991) Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements
ASTM D 2835	(1989) Lubricant for Installation of Preformed Compression Seals in Concrete Pavements

CORPS OF ENGINEERS (COE)

COE CRD-C 513	(1974) Corps of Engineers Specifications for Rubber Waterstops
COE CRD-C 572	(1974) Corps of Engineers Specifications for Polyvinylchloride Waterstops

FEDERAL SPECIFICATIONS (FS)

FS TT-S-00227	(Rev E; Am 3) Sealing Compound: Elastomeric Type, Multi-Component (for Caulking, Sealing, and Glazing in Buildings and Other Structures)

STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION (CALTRANS)

STANDARD SPECIFICATIONS July 1992

1.2 SUBMITTALS

Government approval is required for all submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with SECTION: SUBMITTAL PROCEDURES.

1.2.1 SD-09, Reports

Premolded Expansion Joint Filler Strips; FIO. Compression Seals and Lubricant; FIO. Non-metallic Waterstops; FIO.

Certified manufacturer's test reports shall be provided for premolded expansion joint filler strips, compression seals and lubricant, and non-metallic waterstops to verify compliance with applicable specification.

1.2.2 SD-14, Samples

Field Molded Sealants and Primer; FIO.

Four liters (One gallon) of field-molded sealant and one liter (one quart) of primer (when primer is recommended by the sealant manufacturer) shall be provided for testing.

Non-metallic waterstops and splices; FIO.

Waterstop materials and splice samples shall be submitted for inspection and testing and shall be identified to indicate manufacturer, type of material, size and quantity of material and shipment represented. Each materials sample shall be a piece not less than 305 mm (12 inches) long cut from each 61 m (200 feet) of finished waterstop furnished, but not less than a total of 1.2 linear meters (four linear feet) of each type and size furnished. For spliced segments of waterstops to be installed in the work, one spliced sample of each size and type for every 50 splices made in the factory and every 10 splices made at the job site shall be furnished for inspection and testing. The spliced samples shall be made using straight run pieces with the splice located at the mid-length of the sample and finished as required for the installed waterstop. The total length of each spliced sample shall be not less than 305 mm (12 inches) long.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Premolded Expansion Joint Filler Strips

Premolded expansion joint filler strips shall conform to ASTM D 1751 or ASTM D 1752, Type I, or resin impregnated fiberboard conforming to the physical requirements of ASTM D 1752.

2.1.2 Joint Seals and Sealants

2.1.2.1 Field Molded Sealants

Field molded sealants shall conform to FS TT-S-00227, Type II for vertical joints and Type I for horizontal joints, Class A. Bond breaker material shall be polyethylene tape, coated paper, metal foil or similar type materials. The back-up material shall be compressible, nonshrink, nonreactive with sealant, and nonabsorptive material type such as extruded butyl or polychloroprene foam rubber.

2.1.2.2 Compression Seals and Lubricant

Compression seals shall conform to ASTM D 2628; lubricant for installation shall conform to ASTM D 2835.

2.1.3 Waterstops

2.1.3.1 Non-Metallic Waterstops

Rubber waterstops shall conform to COE CRD-C 513. Polyvinylchloride waterstops shall conform to COE CRD-C 572.

2.2 TESTS, INSPECTIONS, AND VERIFICATIONS

2.2.1 Materials Tests

2.2.1.1 Field-Molded Sealants

Samples of sealant and primer, when use of primer is recommended by the manufacturer, as required in paragraph: FIELD MOLDED SEALANT AND PRIMER shall be tested by and at the expense of the Government for compliance with FS TT-S-00227. If the sample fails to meet specification requirements, new samples shall be provided and the cost of retesting will be deducted from payments due the Contractor at a rate of $300 per sample.

2.2.1.2 Non-Metallic Waterstops

Samples of materials and splices as required in paragraph: WATERSTOPS shall be visually inspected and tested by and at the expense of the Government for compliance with COE CRD-C 513 or COE CRD-C 572 as applicable. If a sample fails to meet the specification requirements, new samples shall be provided and the cost of retesting will be deducted from payments due the Contractor at the rate of $300 per material sample retested and $300 per spliced sample retested.

2.2.2 Splicing Waterstops

2.2.2.1 Procedure and Performance Qualifications

Procedure and performance qualifications for splicing waterstops shall be demonstrated in the presence of the Contracting Officer.

2.2.2.2 Non-Metallic Waterstops

Procedure and performance qualifications for splicing non-metallic waterstops shall be demonstrated by the manufacturer at the factory and the Contractor at the job site by each making three spliced samples of each size and type of finished waterstop.

PART 3 EXECUTION

3.1 INSTALLATION

Joint locations and details, including materials and methods of installation of joint fillers and waterstops, shall be as specified, as indicated, and as directed. In no case shall any fixed metal be continuous through an expansion or contraction joint. In vertical walls, vertical construction joints shall be provided at intervals of 30 to 60 feet measured along the walls or the centerline of the invert.

3.1.1 Expansion Joints

Premolded filler strips shall have oiled wood strips secured to the top thereof and shall be accurately positioned and secured against displacement to clean, smooth concrete surfaces. The wood strips shall be slightly tapered, dressed and of the size required to install filler strips at the desired level below the finished concrete surface and to form the groove for the joint sealant or seals to the size shown on the drawings. Material used to secure premolded fillers and wood strips to concrete shall not harm the concrete and shall be compatible with the joint sealant or seals. The wood strips shall not be removed until after the concrete curing period. The groove shall be thoroughly cleaned of all laitance, curing compound, foreign materials, protrusions of hardened concrete and any dust which shall be blown out of the groove with oil-free compressed air.

3.1.1.1 Joints With Field-Molded Sealant

Joints shall not be sealed when the sealant, air or concrete temperature is less than 4 degrees C (40 degrees F). Bond breaker and back-up material shall be installed where required. Joints shall be primed and filled flush with joint sealant in accordance with the manufacturer's recommendations.

3.1.1.2 Joints With Preformed Compression Seals

The joint seals shall be installed with equipment which shall be capable of installing joint seals to the prescribed depth without cutting, nicking, twisting, or otherwise distorting or damaging the seal and with no more than five percent stretching of the seal. The sides of the joint and, if necessary, the sides of the compression seal shall be covered with a coating of lubricant, and the seal shall be installed to the depth indicated with joint installation equipment. Butt joints shall be coated with liberal applications of lubricant.

3.1.2 Contraction Joints

Joints requiring a bond breaker shall be coated with curing compound or with bituminous paint. Waterstops shall be protected during application of bond breaking material to prevent them from being coated.

3.1.3 Waterstops

Waterstops shall be carefully and correctly positioned during installation to eliminate faulty installation that may result in joint leakage. All waterstops shall be installed so as to form a continuous watertight diaphragm in each joint. Adequate provision shall be made to support and protect the waterstops during the progress of work. Any waterstop punctured or damaged shall be replaced or repaired at the Contractor's expense. The concrete shall be thoroughly consolidated in the vicinity of the waterstop. Suitable guards shall be provided to protect exposed projecting edges and ends of partially embedded waterstops from damage when concrete placement has been discontinued.

3.1.3.1 Splices

Joints in waterstops shall be spliced together by qualified splicers using the approved splicing procedures to form a continuous watertight diaphragm. Splices shall be as followed:

a. Non-Metallic Waterstops - All splices shall be made on a bench in a temporary shop provided at the site of the installation or at the manufacturer's plant. A miter guide and portable power saw shall be used to cut the ends to be joined to insure good alignment and contact between joined surfaces. Continuity of the characteristic features of the cross section of the waterstop (ribs, tabular center axis, protrusions and the like) shall be maintained across the splice.

b. Rubber Waterstops - Splices shall be vulcanized in accordance with the approved procedure.

c. Polyvinylchloride Waterstops - Splices shall be made by heat sealing the adjacent surfaces in accordance with the approved procedure. A thermostatically controlled electrical heat source shall be used to make all splices. The correct temperature at which splices should be made will differ with the material concerned but the applied heat should be sufficient to melt but not char the plastic. Waterstops shall be reformed at splices with a remolding iron with ribs or corrugations to match the pattern of the waterstop. The spliced area, when cooled and bent by hand in as sharp an angle as possible, shall show no sign of separation.

3.2 EXPANSION JOINTS AT BRIDGE FOUNDATIONS AND PIERS

Joints between existing and new concrete structures shall be constructed, filled, and sealed in conformance with the details shown on the plans, the provisions in Section 51-1.12F(3), "Materials and Installation", of the State of California Department of Transportation Standard Specifications and these special provisions.

3.2.1 Sealant at Expansion Joints

Sealant at expansion joints shall be pourable 2-component polyurethane sealant which meets all of the test requirements of State of California Department of Transportation specification 8030-61J-01 as identified in Section 51-1.12F(3), "Materials and Installation", of the Standard Specifications and, in addition, has a minimum pot life of 10 minutes at a temperature of 90 degrees F may be used, at the option of the Contractor. The two components shall be thoroughly mixed in the ratio recommended by the manufacturer with power driven agitators.

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SECTION 03210

STEEL BARS AND WELDED WIRE FABRIC FOR CONCRETE REINFORCEMENT

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SECTION 03210

STEEL BARS AND WELDED WIRE FABRIC FOR CONCRETE REINFORCEMENT

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 315	(1980; R 1986) ACI Detailing Manual: Section Details and Detailing of Concrete Reinforcement
ACI 318-95/318R	(1995) Building Code Requirements for Reinforced Concrete
ACI 301-89	(1989) Specifications for Structural Concrete for Buildings

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 53	(1997) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A 370	(1990a) Mechanical Testing of Steel Products
ASTM A 615	(1996a) Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM A 675	(1995)a Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties
ASTM A 706	(1993a) Low-Alloy Steel Deformed Bars for Concrete Reinforcement

AMERICAN WELDING SOCIETY (AWS)

AWS D1.4	(1994) Structural Welding Code - Reinforcing Steel

1.2 SUBMITTALS

Government approval is required for all submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with SECTION: SUBMITTAL PROCEDURES.

1.2.1 SD-04, Drawings

Fabrication and Placement; GA.

The Contractor shall submit shop drawings which include: reinforcement steel placement drawings; reinforcement steel schedules showing quantity, size, shape, dimensions, weight per foot, total weights and bending details; and details of bar supports showing types, sizes, spacing and sequence.

1.2.2 SD-08, Statements

Butt-Splices; GA.

The Contractor shall submit the proposed procedure for butt-splicing steel bars prior to making the test butt-splices for qualification of the procedure. Properties and analyses of steel bars and splicing materials shall be included in the submitted procedure. Physical properties of splicing sleeves shall include length, inside and outside diameters, and inside surface details.

1.2.3 SD-09, Reports

Materials; GA. Tests, Inspections, and Verifications; GA.

Certified tests reports of reinforcement steel showing that the steel complies with the applicable specifications shall be furnished for each steel shipment and identified with specific lots prior to placement. Three copies of the heat analyses shall be provided for each lot of steel furnished and the Contractor shall certify that the steel conforms to the heat analyses.

1.2.4 SD-18, Records

Materials; GA.

A system of identification which shows the disposition of specific lots of approved materials in the work shall be established and submitted before completion of the contract.

1.3 QUALITY ASSURANCE

The Contractor shall have materials tests performed by an approved laboratory and certify to demonstrate that the materials are in accordance with the specification. Tests shall be performed and certified at the Contractor’s expense.

1.3.1 Reinforcement Steel Tests

Mechanical testing of steel shall be in accordance with ASTM A 370 except as otherwise specified herein or required by the material specifications. Tension tests shall be performed on full cross-section specimens using a gage length that spans the extremities of the specimens with weld or sleeves included. Chemical analyses of steel heats shall show the percentages of carbon, phosphorous, manganese, sulphur and silicon present in the steel.

1.4 WELDING

Welders shall be qualified in accordance with AWS D1.4. Qualification test shall be performed at the worksite and Contractor shall notify the Contracting Officer 24 hours prior to conducting tests. Special welding procedures and welders qualified by others may be accepted as permitted by AWS D1.4.

1.5 DELIVERY AND STORAGE

Reinforcement and accessories shall be stored off the ground on platforms, skids, or other supports. Reinforcement and accessories of different size and shape shall be stored in separate locations for accurate identification. Reinforcement shall be protected from grease, oil and dirt and other contamination.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Steel Bars

Steel bars shall comply with the requirements of ASTM A 615 including Supplementary Requirements, or ASTM A 706, deformed, sizes and lengths indicated. Steel bars shall be grade 60. Bars shall be fabricated in accordance with the Standard Fabricating Tolerances indicated in Figures 4 and 5 of ACI 315.

2.1.2 Accessories

2.1.2.1 Bar Supports

Bar supports shall comply with the requirements of ACI 315. Supports for bars in concrete with formed surfaces exposed to view or to be painted shall be plastic-coated wire, stainless steel or precast concrete supports. Precast concrete supports shall be wedged-shaped, not larger than 3-1/2 by 3-1/2 inches, of thickness equal to that indicated for concrete cover and have an embedded hooked tie-wire for anchorage. Bar supports used in precast concrete with formed surfaces exposed to view shall be the same quality, texture and color as the finish surfaces.

2.1.2.2 Wire Ties

Wire ties shall be 16 gage or heavier black annealed wire.

PART 3 EXECUTION

3.1 FABRICATION AND PLACEMENT

Reinforcement steel and accessories shall be fabricated and placed as specified and indicated and approved shop drawings. Fabrication and placement details of steel and accessories not specified or indicated shall be in accordance with (ACI 315) and ACI 318/318R or as directed. Steel shall be fabricated to shapes and dimensions shown, placed where indicated within specified tolerances and adequately supported during concrete placement. At the time of concrete placement all steel shall be free from loose, flaky rust, scale (except tight mill scale),

mud, oil, grease or any other coating that might reduce the bond with the concrete. No cutting of reinforcing steel by torch will be allowed without approval of the Contracting Officer.

3.1.1 Hooks and Bends

Steel bars shall be mill or field-bent. All steel shall be bent cold unless authorized. No steel bars shall be bent after being partially embedded in concrete unless indicated on the drawings or authorized by the Contracting Officer.

3.1.2 Welding

Welding of steel bars will be permitted only where indicated or authorized by the Contracting Officer. Welding shall be performed in accordance with AWS D1.4 except where otherwise specified or indicated on the drawing.

3.1.3 Placing Tolerances

3.1.3.1 Spacing

The spacing between adjacent bars and the distance between layers of bars may not vary from the indicated position by more than one bar diameter nor more than 1 inch. For placing tolerances not specified in this section, ACI 301 Section 5.6.2 shall govern.

3.1.3.2 Concrete Cover

The minimum concrete cover of main reinforcement steel bars shall be as shown. The allowable variation for minimum cover shall be as follows:

MINIMUM COVER	VARIATION
6 inch	plus 1/2 inch
4 inch	plus 3/8 inch
3 inch	plus 3/8 inch
2 inch	plus 1/4 inch
1-1/2 inch	plus 1/4 inch
1 inch	plus 1/8 inch
3/4 inch	plus 1/8 inch

3.1.4 Splicing

Splices in steel bars shall be made only as required. Bars may be spliced at alternate or additional locations at no additional cost to the Government subject to approval.

3.1.4.1 Lap Splices

Lap splices shall be used only for bars smaller than size 14 and welded wire fabric. Lapped bars may be placed in contact and securely tied or spaced transversely apart to permit the embedment of the entire surface of each bar in concrete. Lapped bars shall not be spaced farther apart than 1/5 the required length of lap or 6 inches.

3.1.4.2 Identification of Splices

The Contractor shall establish and maintain an approved method of identification of all field splices which will indicate the splices and the number assigned each splice made by the splicer.

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SECTION 03301

CAST-IN-PLACE STRUCTURAL CONCRETE

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SECTION 03301

CAST-IN-PLACE STRUCTURAL CONCRETE

PART 1 GENERAL

1.1 RELATED WORK SPECIFIED ELSEWHERE

1.1.1 Expansion, Contraction and Construction Joints in Concrete

SECTION 03150: EXPANSION, CONTRACTION AND CONSTRUCTION JOINTS IN CONCRETE.

1.1.2 Steel Bars for Concrete Reinforcement

SECTION 03210: CONCRETE REINFORCEMENT.

1.1.3 Formwork for Concrete

SECTION 03101: FORMWORK FOR CONCRETE.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 211.1	(1991) Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete
ACI 305R	(1991) Hot Weather Concreting
ACI 301-89	1989) Specifications for Structural Concrete for Buildings

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 31	(1991) Making and Curing Concrete Test Specimens in the Field
ASTM C 33	(1990) Concrete Aggregates
ASTM C 39	(1986) Compressive Strength of Cylindrical Concrete Specimens
ASTM C 42	(1990) Obtaining and Testing Drilled Cores and Sawed Beams in Concrete
ASTM C 70	(1979; R 1985) Surface Moisture in Fine Aggregate

ASTM C 94	(1992) Ready-Mixed Concrete
ASTM C 136	(1992a) Sieve Analysis of Fine and Coarse Aggregates
ASTM C 143	(1990a) Slump of Hydraulic Cement Concrete
ASTM C 150	(1992) Portland Cement
ASTM C 171	(1992) Sheet Materials for Curing Concrete
ASTM C 172	(1990) Sampling Freshly Mixed Concrete
ASTM C 192	(1990a) Making and Curing Concrete Test Specimens in the Laboratory
ASTM C 231	(1991b) Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 260	(1986) Air-Entraining Admixtures for Concrete
ASTM C 309	(1991) Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 494	(1992) Chemical Admixtures for Concrete
ASTM C 566	(1989) Total Moisture Content of Aggregate by Drying
ASTM C 597	(1983; R 1991) Pulse Velocity Through Concrete
ASTM C 618	(1997) Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
ASTM C 803	(1990) Penetration Resistance of Hardened Concrete
ASTM C 805	(1985) Rebound Number of Hardened Concrete
ASTM C 881	(1990) Standard Specifications for Epoxy-Resin-Base Bonding System for Concrete
ASTM C 1077	(1996) Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM D 75	(1987; R 1992) Sampling Aggregates

CORPS OF ENGINEERS (COE)

COE CRD-C 100	(1975) Method of Sampling Concrete Aggregate and Aggregate Sources and Selection of Material for Testing
COE CRD-C 104	(1980) Method of Calculation of Fineness Modulus of Aggregate
COE CRD-C 112	(1969) Surface Moisture in Aggregate by Water Displacement
COE CRD-C 143	(1962) Meters for Automatic Indication of Moisture in Fine Aggregate
COE CRD-C 400	(1963) Requirements for Water for Use in Mixing or Curing Concrete
COE CRD-C 521	(1981) Standard Test Method for Frequency and Amplitude of Vibrators for Concrete
COE CRD-C 621	(1989) Packaged Dry, Hydraulic-Cement Grout (Nonshrink)

CONCRETE PLANT MANUFACTURER'S BUREAU (CPMB)

6th Edition (CRD-C 95)	Concrete Plant Standards

NATIONAL BUREAU OF STANDARDS (NBS) HANDBOOK

44 Specifications, Tolerance and Other Technical Requirements for Commercial Weighing and Measuring Devices (4th Edition 1971 with Replacement Sheets)

1.3 QUALITY ASSURANCE

1.3.1 Aggregate Sources

1.3.1.1 Concrete aggregates can be produced from the approved sources listed below:

a. Lytle Creek, between I-10 and I-15.

b. Gypsum Canyon, between Prado Dam and Villa Park.

c. San Gabriel River, between Santa Fe Dam and Glendora Mountain.

d. Temescal Valley, between Indian Canyon and El Cerrito.

e. Pacoima Canyon, between Foothill and Glenoaks.

1.3.1.2 Concrete aggregates may be furnished from any of the above listed sources or at the option of the Contractor may be furnished from any other source designated by the Contractor and approved by the Contracting Officer, subject to the conditions hereinafter stated.

1.3.1.3 After the award of the contract, the Contractor shall designate in writing only one source or one combination of sources from which he proposes to furnish aggregates. If the Contractor proposes to furnish aggregates from a source or from sources not listed above, he may designate only a single source or single combination of sources for aggregates. Samples for acceptance testing shall be provided as specified herein. If a source for coarse or fine aggregate so designated by the Contractor is not approved for use by the Contracting Officer, the Contractor may not submit for approval other sources but shall furnish the coarse or fine aggregate, as the case may be, from an approved source listed above at no additional cost to the Government. Listing of a concrete aggregate source is not to be construed as approval of all materials from the source. The right is reserved to reject materials from certain localized areas, zones, strata, or channels, when such materials are unsuitable for concrete aggregate as determined by the Contracting Officer. Materials produced from an approved source shall meet all the requirements specified herein.

1.3.2 Preconstruction Sampling and Testing

1.3.2.1 Aggregates

The aggregate sources listed above have in the past been determined to be capable of producing materials of a quality acceptable for this project. The Contractor shall provide samples of aggregates from proposed sources listed and not listed in above. Aggregate samples shall consist of not less than 1,000 pounds of each size coarse aggregate and 1,000 pounds of fine aggregate, taken under the supervision of the Contracting Officer in accordance with COE CRD-C-100. Samples shall be delivered to:

U.S. Army Engineer
Waterways Experiment Station
P.O. Box 631
Vicksburg, MS 39181-0631

Samples shall be delivered to the above address within 15 days after Notice to Proceed. All sampling and shipment of samples shall be at the Contractor's expense. A maximum of 45 days after receipt of the samples will be required to complete evaluation of aggregates from sources listed herein. A maximum of 60 days after receipt of the samples will be required to complete evaluation of aggregates from sources not listed herein. Testing by and at the expense of the Government will be in accordance with the applicable CRD or ASTM test method. Tests to which aggregate may be subjected are specific gravity, absorption, cycles of freezing and thawing in concrete, alkali-aggregate reaction, organic impurities, and any other test necessary to demonstrate that the aggregate is of a quality that is at least equivalent to those sources listed herein. If the source selected by the Contractor fails to supply materials that are at least equivalent to the sources listed as determined by the Government, the Contractor will be required to propose a new source or elect a source listed above to supply aggregates. If the Contractor elects to obtain aggregates from more than one source, samples of aggregates from each source to be evaluated will be obtained as described above. Any testing of additional sources or retesting of sources which fail initially, will be at the expense of the Contractor. The Government reserves the right to reject materials found to be unsuitable when produced from any source, even a source that is listed herein.

1.3.3 Cementitious Materials

At least 60 days in advance of concrete placement, the Contractor shall notify the Contracting Officer of the source of cementitious materials, along with sampling location, brand name, type, and quantity to be used in the manufacture of the concrete. If cement or pozzolan is to be obtained from more than one source, the initial notification shall state the estimated amount to be obtained from each source and the proposed schedule of shipments. No material shall be used until notice has been given by the Contracting Officer that test results are satisfactory, and all movement of materials after sampling shall be as directed.

1.3.4 Air-Entraining Admixture

Air-entraining admixture or other chemical admixtures that have been in storage at the project site for longer than 6 months or that have been subjected to freezing shall be tested at the expense of the Contractor when directed by the Contracting Officer and shall be rejected if test results are not satisfactory.

1.3.5 Prequalified Cement Sources

Cement shall be delivered and used directly from a mill of a producer designated as a qualified source. Samples of cement for check testing will be taken at the project site or concrete-producing plant by a representative of the Contracting Officer for testing at the expense of the Government. A list of prequalified cement sources is available from the Commander and Director, U.S. Army Engineer Waterways Experiment Station, P.O. Box 631, Vicksburg, MS 39181-0631.

1.3.6 Prequalified Pozzolan Sources

Pozzolan shall be delivered and used directly from a producer designated as a qualified source. Samples of pozzolan for check testing will be taken at the project site by a representative of the Contracting Officer for testing at the expense of the Government. A list of prequalified pozzolan sources is available from the Commander and Director, U.S. Army Engineer Waterways Experiment Station, P.O. Box 631, Vicksburg, MS 39181-0631.

1.3.7 Cement

Cement, if not from a prequalified source, will be sampled at the source and stored in sealed bins pending completion of testing. Sampling, testing, and the shipping inspection from the point of sampling, when the point is other than at the site of the work, will be made by or under the supervision of the Government and at its expense. No cement shall be used until notice has been given by the Contracting Officer that test results are satisfactory. In the event of failure, the cement may be resampled and tested at the request of the Contractor, at his expense. When the point of sampling is other than at the site of the work, the fill gates of the sampled bin and conveyances used in shipment will be sealed under Government supervision and kept sealed until shipment from the bin has been completed. If tested cement is rehandled at transfer points, the extra cost of inspection shall be at the Contractor's expense. The cost of testing cement excess to project requirements shall also be at the expense of the Contractor. The charges for testing cement at the expense of the Contractor will be deducted

from the payments due the Contractor at a rate of $1.20 dollars per ton of cement represented by the tests.

1.3.8 Pozzolan

Pozzolan if not from a prequalified source, will be sampled at the source and stored in sealed bins pending completion of certain tests. Pozzolan will also be sampled at the site when determined necessary. All sampling and testing will be by and at the expense of the Government. Release for shipment and approval for use will be based on compliance with 7-day lime-pozzolan strength requirements and other physical and chemical and uniformity requirements for which tests can be completed by the time the 7-day lime-pozzolan strength test is completed. Release for shipment and approval for use on the above basis will be contingent on continuing compliance with the other requirements of the specifications. If a bin fails, the contents may be resampled and tested at the Contractor's expense. In this event the pozzolan may be sampled as it is loaded into cars, trucks, or barges provided they are kept at the source until released for shipment. Unsealing and resealing of bins and sealing of shipping conveyances will be done by or under the supervision of the Government. Shipping conveyances will not be accepted at the site of the work unless received with all seals intact. If pozzolan is damaged in shipment, handling, or storage, it shall be promptly removed from the site of the work. Pozzolan that has not been used within 6 months after testing shall be retested at the expense of the Contractor when directed by the Contracting Officer and shall be rejected if the test results are not satisfactory. If tested pozzolan is rehandled at transfer points, the extra cost of inspection shall be at the Contractor's expense. The cost of testing excess pozzolan shall be at the Contractor's expense at a rate of $2.00 dollars per ton. The amount will be deducted from payment to the Contractor.

1.3.9 Curing Compounds

Curing compounds will be accepted based on compliance with applicable specifications.

1.3.10 Construction Testing by Government

The Government will sample and test aggregates and concrete to determine compliance with the specifications. The Contractor shall provide facilities and labor as may be necessary for procurement of representative test samples. Samples of aggregates will be obtained at the point of batching in accordance with ASTM D 75. Concrete will be sampled in accordance with ASTM C 172. Slump and air content will be determined in accordance with ASTM C 143 and ASTM C 231, respectively. Compression test specimens will be made and laboratory cured in accordance with ASTM C 31, and compression test specimens tested in accordance with ASTM C 39.

1.4 EVALUATION AND ACCEPTANCE

1.4.1 Concrete Strength

The strength of the concrete will be considered satisfactory so long as the average of all sets of three consecutive test results equals or exceeds the required specified strength f'_c and no individual test (average of two cylinders)

result falls below the specified strength f'_c by more than 500 pounds per square inch. Additional analysis or testing may be required at the Contractor's expense when the strength of the concrete in the structure is considered potentially deficient.

1.4.1.1 Investigation of Low-Strength Test Results

When any strength test of standard-cured test cylinders falls below the specified strength requirement by more than 500 pounds per square inch or if tests of field-cured cylinders indicate deficiencies in protection and curing, steps shall be taken to assure that the load-carrying capacity of the structure is not jeopardized. Nondestructive testing in accordance with ASTM C 597, C 803, or C 805 may be permitted by the Contracting Officer to determine the relative strengths at various locations in the structure as an aid in evaluating concrete strength in place or for selecting areas to be cored. Such tests, unless properly calibrated and correlated with other test data, shall not be used as a basis for acceptance or rejection.

1.4.1.2 Testing of Cores

When the strength of concrete in place is considered potentially deficient, cores shall be obtained and tested in accordance with ASTM C 42. At least three representative cores shall be taken from each member or area of concrete in place that is considered potentially deficient. The location of cores will be determined by the Contracting Officer to least impair the strength of the structure. If the concrete in the structure will be dry under service conditions, the cores shall be air dried (temperature 60 to 80 degrees F, relative humidity less than 60 percent) for 7 days before testing and shall be tested dry. If the concrete in the structure will be more than superficially wet under service conditions, the cores shall be tested after moisture conditioning in accordance with ASTM C 42. Concrete in the area represented by the core testing will be considered adequate if the average strength of the cores is equal to at least 85 percent of the specified strength requirement and if no single core is less than 75 percent of the specified strength requirement.

1.4.2 Construction Tolerances

Variation in alignment, grade, and dimensions of the structures from the established alignment, grade, and dimensions shown on the drawings shall be within the tolerances specified in the following table:

TABLE I. TOLERANCES FOR BRIDGES, EROSION PROTECTION STRUCTURES, AND HYDRAULIC STRUCTURES

(1)	Departure from established alignment		1 inch
(2)	Departure from established grades		1 inch
(3)	Variation from the plumb or the specified batter in the lines and surfaces of walls	Exposed, in 10 feet	1/2 inch
		Backfilled, in 10 feet	1 inch
(4)	Variation from the level or from the		

	grades indicated on the drawings in slabs, horizontal grooves	Exposed, in 10 feet..... 1/2 inch Backfilled, in 10 feet... 1 inch
(5)	Variation in cross-sectional dimensions of slabs, walls, and similar parts	Minus..... 1/4 inch Plus..... 1/2 inch
(6)	Footings:	
	a. Variation of dimensions in plan	Minus..... 1/2 inch Plus..... 2 inches when formed or plus 3 inches when placed against unformed excavation.
	b. Misplacement of eccentricity	2 percent of the footing width in the direction of misplacement but not more than..... 2 inches
	c. Reduction in thickness	Minus..... 5 percent of specified thickness
(7)	Variation in the sizes and locations of slab and wall openings	..... 1/2 inch

1.4.3 Surface Requirements

The surface requirements for the classes of finish required by SECTION: FORMWORK FOR CONCRETE, shall be as hereinafter specified. Allowable irregularities are designated "abrupt" or "gradual" for purposes of providing for surface variations. Offsets resulting from displaced, misplaced, or mismatched forms, or sheathing, or by loose knots in sheathing, or other similar form defects, shall be considered "abrupt" irregularities. Irregularities resulting from warping, unplaneness, or similar uniform variations from planeness, or true curvature, shall be considered "gradual" irregularities. "Gradual" irregularities will be checked for compliance with the prescribed limits with a 5-foot template, consisting of a straightedge for plane surfaces and a shaped template for curved or warped surfaces. In measuring irregularities, the straightedge or template may be placed anywhere on the surface in any direction, with the testing edge held parallel to the intended surface.

	Irregularities	
Class of Finish	Abrupt, inches	Gradual, inches
C	*	1/4
D	1	1

*Variation for Class C finish shall not exceed zero positive and 1/8 inch negative in the direction of flow of the water.

1.4.4 Appearance

Permanently exposed surfaces shall be cleaned, if stained or otherwise discolored, by a method that does not harm the concrete and that is approved by the Contracting Officer.

1.5 SUBMITTALS

1.5.1 Test Reports

1.5.1.1 Concrete Mixture Proportions

Concrete mixture proportions shall be determined by the Contractor, in accordance with the requirements in paragraph: Mixture Proportioning, and submitted for approval. The proportions of all ingredients and nominal maximum coarse aggregate size that will be used in the manufacture of each quality of concrete shall be stated. Proportions shall indicate the weight of cement, pozzolan and water; the weights of aggregates in a saturated surface-dry condition; and the quantities of admixtures. The submission shall be accompanied by test reports from a laboratory complying with ASTM C 1077 which show that proportions thus selected will produce concrete of the qualities indicated. No substitution shall be made in the source or type of materials used in the work without additional tests to show that the new materials and quality of concrete are satisfactory.

1.5.1.2 Cement and Pozzolan

Cement and pozzolan will be accepted on the basis of the manufacturer's certification of compliance, accompanied by mill test reports that materials meet the requirements of the specification under which they are furnished. Certification and mill test reports shall identify the particular lot furnished. No cement or pozzolan shall be used until notice of acceptance has been given by the Contracting Officer. Cement and pozzolan will be subject to check testing from samples obtained at the mill, at transfer points, or at the project site, as scheduled by the Contracting Officer, and such sampling will be by or under the supervision of the Government at its expense. Material not meeting specifications shall be promptly removed from the site of work.

1.5.1.3 Grout

1.5.1.3.1 General

Descriptive literature of the grout proposed for use shall be furnished together with a certificate from the manufacturer stating that it is suitable for the application or exposure for which it is being considered. In addition, a detailed plan shall be submitted for approval, showing equipment and procedures proposed for use in mixing and placing the grout.

1.5.1.3.2 Prepackaged Material

Prepackaged material requiring only the addition of water will be accepted on the basis of certified laboratory test results showing that the material meets the requirements of COE CRD-C 621. When fine aggregate is to be added, the Contractor shall also furnish for approval the design mix proportions together with certified copies of laboratory test results indicating that the mix is in conformance with the requirements of COE CRD-C 621.

1.5.1.3.3 Mixture Proportions

Mixture proportions using a volume-change controlling ingredient shall be submitted for approval. The submittal shall include the design mix proportions of all ingredients and certified copies of laboratory test results indicating that the materials and the mix is in conformance with the requirements of COE CRD-C 621.

1.5.2 Manufacturer's Certificate

1.5.2.1 Impervious-Sheet Curing Materials

Impervious-sheet curing materials shall be certified for compliance with all specification requirements.

1.5.2.2 Air-Entraining Admixture

Air-entraining admixture shall be certified for compliance with all specification requirements.

1.5.2.3 Curing Compound

Curing compound shall be certified for compliance with all specification requirements.

1.5.3 Review of Plant, Equipment, and Methods

1.5.3.1 Batch Plant

Details of the data on concrete plant shall be submitted for review by the Contracting Officer for conformance with paragraph: Batching Plant.

1.5.3.2 Mixers

The make, type, and capacity of concrete mixers proposed for mixing concrete shall be submitted for review by the Contracting Officer for conformance with paragraph: Mixers. The results of the initial mixer uniformity tests as required in paragraph: Mixer Uniformity shall be submitted at least 5 days prior to the initiation of placing.

1.5.3.3 Conveying Equipment

The methods and equipment for transporting, handling, and depositing the concrete shall be submitted for review by the Contracting Officer for conformance with paragraph: Conveying Equipment.

1.5.3.4 Placing

All placing equipment and methods shall be submitted for review by the Contracting Officer for conformance with paragraph: Placing.

1.5.3.5 Joint Cleanup

The method and equipment proposed for joint cleanup and waste disposal shall be submitted for review by the Contracting Officer for conformance with paragraph: Construction Joint Treatment.

1.5.3.6 Curing

The curing medium and methods to be used shall be submitted for review by the Contracting Officer for conformance with paragraph: Curing and Protection.

1.5.3.7 Hot-Weather Requirements

If concrete is to be placed under hot-weather conditions, the proposed materials and methods meeting the requirements of paragraphs: Hot Weather Placing and Unformed Surfaces, will be approved by the Contracting Officer.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Cementitious Materials

Cementitious materials shall be Portland cement or Portland cement in combination with pozzolan and shall conform to appropriate specifications listed below.

2.1.1.1 Portland Cement

ASTM C 150, Type II including false set requirements and low alkali.

2.1.1.2 High-Early-Strength Portland Cement

ASTM C 150, Type III with tricalcium aluminate limited to 8 percent, low alkali, used only when specifically approved in writing.

2.1.1.3 Pozzolan

Pozzolan shall conform to ASTM C 618, Class F, with loss on ignition limited to 6 percent.

2.1.2 Aggregates

Aggregates shall be produced from the sources listed and under the conditions described in paragraph: Quality Assurance, subparagraph Aggregates. Fine and coarse aggregates shall conform to the grading requirements of ASTM C 33. The nominal maximum size shall be as listed in paragraph: Nominal Maximum-Size Coarse Aggregate. The proposed gradations to be used shall be submitted to the Contracting Officer for approval.

2.1.3 Admixtures

Admixtures to be used, when required or permitted, shall conform to the appropriate specification listed below:

2.1.3.1 Air-Entraining Admixture

ASTM C 260.

2.1.3.2 Water-Reducing or Retarding Admixtures

ASTM C 494, Type A, B, or D.

2.1.4 Curing Materials

2.1.4.1 Impervious-Sheet Materials

ASTM C 171, type optional, except polyethylene film, if used, shall be white opaque.

2.1.4.2 Membrane-Forming Curing Compound

ASTM C 309, Type 1-D or 2,Class B. Nonpigmented compound shall contain a fugitive dye. The loss of water for both pigmented and nonpigmented curing compounds when tested as specified, shall be not more than 0.03 pound per square foot in 24 hours nor more than 0.09 pound per square foot in 72 hours.

2.1.5 Water

Water for mixing and curing shall be fresh, clean, drinkable, and free of injurious amounts of oil, acid, salt, or alkali, except that undrinkable water may be used if it meets the requirements of COE CRD-C 400.

2.2 MIXTURE PROPORTIONING

2.2.1 Quality and Location

For each portion of the structure, mixture proportions shall be selected so that the following strength and water-cement ratio requirements are met.

2.2.1.1 Strength

Specified compressive strength f'_c shall be as follows:

Compressive Strength	Structure or Portion of Structure
3,000 - 28 days	Walls, side slopes and cast-in-place structures not otherwise specified.
4,000 - 28 days	Cast-In-Place Box Culverts.
5,000 - 28 days	Invert concrete.

2.2.1.2 Maximum Water-Cement Ratio

Maximum water-cement ratio shall be 0.45 for all concrete structures.

2.2.2 Nominal Maximum-Size Coarse Aggregate

Nominal maximum-size coarse aggregate for parapet and retaining walls and side slopes shall be 1 inch, and 1½ inches for footings and invert, except 3/4-inch nominal maximum-size coarse aggregate shall be used when any of the following conditions exist: the narrowest dimension between sides of forms is less than 7-1/2 inches, the depth of the slab is less than 4-1/2 inches, or the minimum clear spacing between reinforcing is less than 2 inches.

2.2.3 Air Content

Air content as determined by ASTM C 231 shall be between 4 and 6 percent.

2.2.4 Slump

The slump shall be determined in accordance with ASTM C 143 and shall be within the range of 1 to 3 inches for footings and invert, and 1 to 5 inches for parapet and retaining walls.

2.2.5 Concrete Proportioning

Trial design batches and testing requirements for various qualities of concrete specified shall be the responsibility of the Contractor. Samples of approved aggregates shall be obtained in accordance with the requirements of ASTM D 75. Samples of materials other than aggregate shall be representative of those proposed for the project and shall be accompanied by the manufacturer's test reports indicating compliance with applicable specified requirements. Trial mixtures having proportions, consistencies, and air content suitable for the work shall be made based on methodology described in ACI 211.1, using at least three different water-cement ratios, which will produce a range of strength encompassing those required for the work. The water-cement ratios required in paragraph: Maximum Water-Cement Ratio, will be converted to a weight ratio of water to cement plus pozzolan by weight equivalency as described in ACI 211.1. Trial mixtures shall be designed for maximum permitted slump and air content. The temperature of concrete in each trial batch shall be reported. For each maximum aggregate size selected at each water-cement ratio, at least three test cylinders for each test age shall be made and cured in accordance with ASTM C 192. They shall be tested at 7 and 28 days in accordance with ASTM C 39. From these test results, a curve will be plotted showing the relationship between water-cement ratio and strength.

2.2.6 Average Strength

In meeting the water-cement ratio and strength requirements specified in paragraph: Strength above, the selected mixture proportion shall produce an average strength (f_{cr}) exceeding the specified strength f'_c by the amount indicated below with a water-cement ratio at or below that specified above. Where a concrete production facility has test records, a standard deviation shall be established. Test records from which a standard deviation is calculated shall represent materials, quality control procedures, and conditions similar to those expected, shall represent concrete produced to meet a specified strength or strengths (f'_c) within 1,000 pounds per square inch of that specified for proposed work, and shall consist of at least 30 consecutive tests. A strength test shall be the average of the strengths of two cylinders made from the same sample of

concrete and tested at 28 days or at another test age designated for determination of f'_c.

2.2.6.1 Required Average Compressive Strength

Required average compressive strength f_{cr} used as the basis for selection of concrete proportions shall be the larger of the equations that follow using the standard deviation as determined above:

$f_{cr} = f'_c + 1.34S$ where S = standard deviation
$f_{cr} = f'_c + 2.33S - 500$

2.2.6.2 Modification Factor for Standard Deviation

Where a concrete production facility does not have test records meeting the requirements above but does have a record based on 15 to 29 consecutive tests, a standard deviation may be established as the product of the calculated standard deviation and a modification factor from the following table:

No. of Tests*	Modification Factor for Standard Deviation
less than 15	Use paragraph 2.2.6.3 hereinafter
15	1.16
20	1.08
25	1.03
30 or more	1.00

* Interpolate for intermediate numbers of tests.

2.2.6.3 Determining Required Average Strength

When a concrete production facility does not have field strength test records for calculation of the standard deviation, the required average strength f_{cr} shall be determined as follows:

If the specified compressive strength f'_c is 3,000 to 5,000 psi, $f_{cr} = f'_c + 1,200$. If the specified compressive strength f'_c is over 5,000 psi, $f_{cr} = f'_c + 1,400$.

2.3 PRODUCTION EQUIPMENT

2.3.1 Batching Plant

Batching plant shall conform to the requirements of the CRD-C-95. Concrete Plant Standards of CPMB and as specified; however, rating plates attached to batch plant equipment are not required.

2.3.1.1 Equipment

The batching controls shall be semiautomatic or automatic. The semiautomatic batching system shall be provided with interlocks such that the discharge device cannot be actuated until the indicated material is within the applicable tolerance. The batching system shall be equipped with an accurate recorder or

recorders that meet the requirement of the Concrete Plant Standards of CPMB. Separate bins or compartments shall be provided for each size group of aggregate cement and pozzolan. Aggregates shall be weighed either in separate weigh batchers with individual scales or cumulatively in one weigh batcher on one scale. Aggregate shall not be weighed in the same batcher with cement and pozzolan. If both cement and pozzolan are used, they may be batched cumulatively provided that the Portland cement is batched first. If measured by weight, water shall not be weighed cumulatively with another ingredient. Water batcher filling and discharging valves shall be so inter-locked that the discharge valve cannot be opened before the filling valve is fully closed. An accurate mechanical device for measuring and dispensing each admixture shall be provided. Each dispenser shall be interlocked with the batching and discharging operation of the water so that each admixture is separately batched and discharged automatically in a manner to obtain uniform distribution throughout the batch in the specified mixing period. Admixtures shall not be combined prior to introduction of water or sand. The plant shall be arranged so as to facilitate the inspection of all operations at all times. Suitable facilities shall be provided for obtaining representative samples of aggregates from each bin or compartment.

2.3.1.2 Scales

The weighing equipment shall conform to the applicable requirements of NBS Handbook 44, except that the accuracy shall be plus or minus 0.2 percent of scale capacity. The Contractor shall provide standard test weights and any other auxiliary equipment required for checking the operating performance of each scale or other measuring devices. The tests shall be made at the frequency required in paragraph: Scales, and in the presence of a Government inspector.

2.3.1.3 Batching Tolerances

2.3.1.3.1 Weighing Tolerances

Whichever of the following tolerances is greater shall apply, based on required scale reading.

Material	Percent of Required Weight	Percent of Scale Capacity
Cementitious materials	±1	±0.3
Aggregate	±2	±0.3
Water	±1	±0.3
Admixture	±3	±0.3

2.3.1.3.2 Volumetric Tolerances

For volumetric batching equipment, the following tolerances shall apply to the required volume of material being batched:

Water: Plus or minus 1 percent
Admixtures: Plus or minus 3 percent

2.3.1.4 Moisture Control

The plant shall be capable of ready adjustment to compensate for the varying moisture content of the aggregates and to change the weights of the materials being batched. An electric moisture meter complying with the provisions of COE CRD-C 143 shall be provided for measuring moisture in the fine aggregate. The sensing element shall be arranged so that the measurement is made near the batcher charging gate of the sand bin or in the sand batcher.

2.3.2 Mixers

2.3.2.1 General

The mixers shall not be charged in excess of the capacity recommended by the manufacturer. The mixers shall be operated at the drum or mixing blade speed designated by the manufacturer. The mixers shall be maintained in satisfactory operating condition, and the mixer drums shall be kept free of hardened concrete. Should any mixer at any time produce unsatisfactory results, its use shall be promptly discontinued until it is repaired.

2.3.2.2 Concrete Plant Mixers

Concrete plant mixers shall be tilting, nontilting, horizontal-shaft, vertical-shaft type, or pug mill type and shall be provided with an acceptable device to lock the discharge mechanism until the required mixing time has elapsed. The mixing time and uniformity shall conform to all the paragraphs in ASTM C 94 applicable to central-mixed concrete.

2.3.2.3 Truck Mixers

Truck mixers, the mixing of concrete therein, and concrete uniformity shall conform to the requirements of ASTM C 94. A truck mixer may be used either for complete mixing (transit-mixed) or to finish the partial mixing done in a stationary mixer (shrink-mixed). Each truck shall be equipped with two counters from which it will be possible to determine the number of revolutions at mixing speed and the number of revolutions at agitating speed.

2.4 CONVEYING EQUIPMENT

2.4.1 General

Concrete shall be conveyed from mixer to forms as rapidly as practicable and within the time interval in paragraph: Time Interval Between Mixing and Placing by methods that will prevent segregation or loss of ingredients. Any concrete transferred from one conveying device to another shall be passed through a hopper that is conical in shape and shall not be dropped vertically more than 5 feet, except where suitable equipment is provided to prevent segregation and where specifically authorized. Telephonic or other satisfactory means of rapid communication between the mixing plant and the forms in which concrete is being placed shall be provided and available for use by Government Inspectors.

2.4.2 Buckets

The interior hopper slope shall be not less than 58 degrees from the horizontal, the minimum dimension of the clear gate opening shall be at least 5 times the

nominal maximum-size aggregate, and the area of the gate opening shall not be less than 2 square feet. The maximum dimension of the gate opening shall not be greater than twice the minimum dimension. The bucket gates shall be essentially grout tight when closed and may be manually, pneumatically, or hydraulically operated except that buckets larger than 2 cubic yards shall not be manually operated. The design of the bucket shall provide means for positive regulation of the amount and rate of deposit of concrete in each dumping position.

2.4.3 Transfer Hoppers

Concrete may be charged into nonagitating hoppers for transfer to other conveying devices. Transfer hoppers shall be capable of receiving concrete directly from delivery vehicles and have conical-shaped discharge features. The machine shall be equipped with a hydraulically operated gate and with a means of external vibration to effect complete and facile discharge. Concrete shall not be held in nonagitating transfer hoppers more than 30 minutes.

2.4.4 Trucks

Truck mixers operating at agitating speed or truck agitators used for transporting plant-mixed concrete shall conform to the requirements of ASTM C 94. Non-agitating equipment may be used for transporting plant-mixed concrete over a smooth road when the hauling time is less than 15 minutes. Bodies of nonagitating equipment shall be smooth, watertight, metal containers specifically designed to transport concrete, shaped with rounded corners to minimize segregation, and equipped with gates that will permit positive control of the discharge of the concrete.

2.4.5 Chutes

When concrete can be placed directly from a truck mixer, agitator, or nonagitating equipment, the chutes attached to this equipment may be used. A discharge deflector shall be used when required by the Contracting Officer. Separate chutes and other similar equipment will not be permitted for conveying concrete except when specifically approved.

2.4.6 Belt Conveyors

Belt conveyors may be used when approved. Such conveyors shall be designed and operated to assure a uniform flow of concrete from mixer to final place of deposit without segregation of ingredients or loss of mortar and shall be provided with positive means for preventing segregation of the concrete at the transfer points and the point of placing. Belt conveyors shall be constructed such that the idler spacing shall not exceed 36 inches. If concrete is to be placed through installed horizontal or sloping reinforcing bars, the conveyor shall discharge concrete into a pipe or elephant trunk that is long enough to extend through the reinforcing bars. In no case shall concrete be discharged to free fall through the reinforcing bars.

2.4.7 Pump Placement

Concrete may be conveyed by positive displacement pump when approved. The pumping equipment shall be piston or squeeze pressure type. The pipeline shall be rigid

steel pipe or heavy-duty flexible hose. The inside diameter of the pipe shall be at least 3 times the nominal maximum-size coarse aggregate in the concrete mixture to be pumped but not less than 4 inches. The maximum-size coarse aggregate shall not be reduced to accommodate the pumps. The distance to be pumped shall not exceed limits recommended by the pump manufacturer. The concrete shall be supplied to the concrete pump continuously. When pumping is completed, concrete remaining in the pipeline shall be ejected without contamination of concrete in place. After each operation, equipment shall be thoroughly cleaned, and flushing water shall be wasted outside of the forms.

PART 3 EXECUTION

3.1 PREPARATION FOR PLACING

3.1.1 Embedded Items

Before placement of concrete, care shall be taken to determine that all embedded items are firmly and securely fastened in place as indicated on the drawings, or required. Embedded items shall be free of oil and other foreign matter such as loose coatings or rust, paint, and scale. The embedding of wood in concrete will be permitted only when specifically authorized or directed. Voids in sleeves, inserts, and anchor slots shall be filled temporarily with readily removable materials to prevent the entry of concrete into voids.

3.1.2 Concrete on Earth Foundations

Earth surfaces upon which concrete is to be placed shall be clean, damp, and free from standing or running water. Prior to placement of concrete, the earth foundation shall have been satisfactorily compacted in accordance with the provisions of SECTION: FILLS AND SUBGRADE PREPARATION. Concrete shall not be placed on a soft, spongy and yielding foundation. Additionally, the foundation shall be inspected by the Contractor prior to concrete placement in order to certify that it is ready to receive concrete. The results of each inspection shall be submitted in writing.

3.1.3 Construction Joint Treatment

3.1.3.1 General

Concrete surfaces to which other concrete is to be bonded shall be prepared for receiving the next lift or adjacent concrete by cleaning with either air-water cutting, sandblasting, high-pressure water jet, or other approved method. The entire surface of the existing concrete shall be cleaned to a depth of not less than 1/4 inch and to such additional depth where necessary to expose a sound, unweathered concrete surface that is not contaminated by oils or other foreign matter.

3.1.3.2 Cleaning

3.1.3.2.1 Air-Water Cutting

Air-water cutting of a construction joint shall be performed at the proper time and only on horizontal construction joints. The surface shall be cut with an

air-water jet to remove all laitance and to expose clean, sound, fine aggregate, but not so as to undercut the edges of the larger particles of aggregate. The air pressure used in the jet shall be 100 pounds per square inch plus or minus 10 pounds per square inch, and the water pressure shall be just sufficient to bring the water into effective influence of the air pressure. After cutting, the surface shall be washed and rinsed as long as there is any trace of cloudiness of the wash water. The surface shall again be washed just prior to placing the succeeding lift. Where necessary to remove accumulated laitance, coatings, stains, debris, and other foreign material, sandblasting will be required as the last operation before placing the next lift.

3.1.3.2.2 High-Pressure Water Jet

A stream of water under a pressure of not less than 3,000 pounds per square inch may be used for cleaning. Its use shall be delayed until the concrete is sufficiently hard so that only the surface skin or mortar is removed and there is no undercutting of coarse-aggregate particles. Where the cleaning occurs more than 2 days prior to placing the next lift or where work in the area subsequent to the cleaning causes dirt or debris to be deposited on the surface, the surface shall be cleaned again as the last operation prior to placing the next lift. If the water jet is incapable of a satisfactory cleaning, the surface shall be cleaned by sandblasting.

3.1.3.2.3 Sandblasting

When employed in the preparation of construction joints, sandblasting shall be performed as the final operation completed before placing the following lift. The operation shall be continued until all accumulated laitance, coatings, stains, debris, and other foreign materials are removed. The surface of the concrete shall then be washed thoroughly to remove all loose materials. The surface shall again be washed just prior to placing the succeeding lift.

3.1.3.2.4 Waste Disposal

The method used in disposing of waste water employed in cutting, washing, and rinsing of concrete surfaces shall be such that the waste water does not stain, discolor, or affect exposed surfaces of the structures, or damage the environment of the project area. The method of disposal shall be subject to approval.

3.1.3.2.5 Surface Condition

The surface of the lift shall be damp at the time of placement of the next lift and shall be free of standing water.

3.2 PLACING

3.2.1 General

Concrete placement will not be permitted when, in the opinion of the Contracting Officer, weather conditions prevent proper placement and consolidation. Concrete shall be deposited as close as possible to its final position in the forms and, in so depositing, there shall be no vertical drop greater than 5 feet except where suitable equipment is provided to prevent segregation and where specifically

authorized. Depositing of the concrete shall be so regulated that it may be effectively consolidated in horizontal layers 1-1/2 feet or less in thickness with a minimum of lateral movement. The amount deposited in each location shall be that which can be readily and thoroughly consolidated. The surfaces of construction joints shall be kept continuously wet for the first 12 hours during the 24-hour period prior to placing concrete. Free water shall be removed prior to placement of concrete. Sufficient placing capacity shall be provided so that concrete placement can be kept plastic and free of cold joints while concrete is being placed.

3.2.2 Time Interval Between Mixing and Placing

Concrete shall be placed within 30 minutes after discharge into non-agitating equipment. When concrete is truck mixed or when a truck mixer or agitator is used for transporting concrete mixed by a concrete plant mixer, the concrete shall be delivered to the site of the work, and discharge shall be completed within 1-1/2 hours after introduction of the cement to the aggregates. When the length of haul makes it impossible to deliver truck-mixed concrete within these time limits, batching of cement and a portion of the mixing water shall be delayed until the truck mixer is at or near the construction site.

3.2.3 Cold-Weather Placing

Concrete shall not be placed without a procedure approved in accordance with paragraph: Cold-Weather Requirements when the concrete is likely to be subjected to freezing temperatures before the expiration of the curing period. The ambient temperature of the space adjacent to the concrete placement and surfaces to receive concrete shall be above 32 degrees F. The placing temperature of the concrete having a minimum dimension less than 12 inches shall be between 55 and 75 degrees F. The placing temperature of the concrete having a minimum dimension greater than 12 inches shall be between 50 and 70 degrees F. Heating of the mixing water or aggregates will be required to regulate the concrete-placing temperatures. Materials entering the mixer shall be free from ice, snow, or frozen lumps. Salt, chemicals, or other materials shall not be mixed with the concrete to prevent freezing, except that an approved chemical accelerator may be used.

3.2.4 Hot-Weather Placing

Concrete shall be properly placed and finished with approved submittal procedures in accordance with paragraph: Hot-Weather Requirements (Reference ACI 305R). The concrete-placing temperature shall not exceed 90 degrees F. Cooling of the mixing water and/or aggregates will be required to obtain an adequate placing temperature. An approved retarder may be used to facilitate placing and finishing. Steel forms and reinforcement shall be cooled prior to concrete placement when steel temperatures are greater than 120 degrees F. Conveying and placing equipment shall be cooled if necessary to maintain proper concrete-placing temperature.

3.2.5 Consolidation

Immediately after placing, each layer of concrete shall be consolidated by internal vibrating equipment. Vibrators will not be used to transport concrete within the forms. Hand spading may be required if necessary with internal vibrating along formed surfaces permanently exposed to view. Form or surface vibrators shall not be used. Spare vibrators shall be kept on site during all concrete placement operations. Consolidation will proceed independently of all other placing operations. Vibrators for consolidation will not be attached to Bidwell Type or any other screeding or leveling equipment selected by the Contractor.

Application	Head Diameter inches	Frequency VPM	Amplitude inches
Thin walls, beams, etc.	1-1/4 - 2-1/2	9,000 - 13,500	0.02 - 0.04
General construction	2 - 3-1/2	8,000 - 12,000	0.025 - 0.05

The frequency and amplitude shall be within the range indicated in the table above as determined in accordance with paragraph: Vibrators. The vibrator shall be inserted vertically at uniform spacing over the entire area of placement. The distance between insertions shall be approximately 1-1/2 times the radius of action of the vibrator. The vibrator shall penetrate rapidly to the bottom of the layer and at least 6 inches into the preceding layer if such exists. It shall be held stationary until the concrete is consolidated and then withdrawn slowly.

3.3 FINISHING

3.3.1 Unformed Surfaces

3.3.1.1 General

The ambient temperature of spaces adjacent to surfaces being finished shall be not less than 50 degrees F. In hot weather when the rate of evaporation of surface moisture, as determined by use of Figure 2.1.5 of ACI 305R, may reasonably be expected to exceed 0.2 pound per square foot per hour, provisions for windbreaks, shading, fog spraying, or wet covering with a light-colored material shall be made in advance of placement, and such protective measures shall be taken as quickly as finishing operations will allow. All unformed surfaces that are not to be covered by additional concrete or backfill shall have a float finish, unless a trowel finish is specified, and shall be true to the elevation shown on the drawings. Surfaces to receive additional concrete or backfill shall be brought to the elevation shown on the drawings and left true and regular. Exterior surfaces shall be sloped for drainage unless otherwise shown on the drawing or as directed. Joints shall be carefully made with a jointing or edging tool. The finished surfaces shall be protected from stains or abrasions.

3.3.1.2 Float Finish

Surfaces shall be screeded and darbied or bullfloated to bring the surface to the required finish level with no coarse aggregate visible. No water, cement, or mortar shall be added to the surface during the finishing operation. The

concrete, while still green but sufficiently hardened to bear a man's weight without deep imprint, shall be floated to a true and even plane. Floating may be performed by use of suitable hand floats or power-driven equipment. Hand floats shall be made of magnesium or aluminum. Tolerance for a floated finish shall be true plane within 5/16 inch in 10 feet as determined by a 10-foot straightedge placed anywhere on the slab in any direction.

3.3.1.3 Trowel Finish

A trowel finish shall be applied to the following surfaces: top of walls. Concrete surfaces shall be finished with a float finish, and after surface moisture has disappeared, the surface shall be troweled to a smooth, even, dense finish free from blemishes including trowel marks. Tolerance shall be true planes within 5/16 inch in 10 feet as determined by a 10-foot straightedge placed anywhere on the slab in any direction.

3.3.1.4 Steel Broom Finish. A steel broom finish shall be applied to the invert access ramp surface. Brooming shall be transverse to the ramp centerline. Brooming shall provide a rough surface with scratches between 1/16 inch and 1/8 inch.

3.3.2 Formed Surfaces

After form removal, all fins and loose materials shall be removed. All voids and honeycombs exceeding 1/2 inch in diameter and all tie-rod holes shall be reamed or chipped and filled with dry-pack mortar. Defective areas larger than 36 square inches in any surface, permanently exposed or not, shall be delineated in a rectangular shape by a saw cut a minimum depth of one inch. All defective concrete in the delineated area shall be removed and replaced with carefully placed and compacted concrete. The cement used in the mortar or concrete for all surfaces shall be a blend of Portland cement and white cement properly proportioned so that the final color when cured will be the same as adjacent concrete. Temperature of the concrete, ambient air, replacement concrete, or mortar during remedial work including curing shall be above 50 degrees F. The prepared area shall be dampened, brush-coated with a neat cement grout or with an approved epoxy resin, and filled with mortar or concrete. The mortar shall consist of 1 part cement to 2-1/2 parts fine aggregate. The quantity of mixing water shall be the minimum necessary to obtain a uniform mixture and to permit placing. Mortar shall be thoroughly compacted in place and struck off to adjacent concrete. Replacement concrete shall be drier than the usual mixture and thoroughly tamped into place and finished. Forms shall be used if required. Metal tools shall not be used to finish permanently exposed surfaces. The patched areas shall be cured for 7 days.

3.4 DEMONSTRATION SECTION

3.4.1 General

Prior to placing concrete for parapet and retaining walls, the Contractor shall construct a concrete wall with the approved concrete mix proportion, to demonstrate his proposed operations of production placement and curing method. The section shall demonstrate procedure and capability of grade preparation, reinforcement, form work, concrete placing, vibrating, finishing, and texture

within the tolerances specified. The demonstration section shall be 25 feet in length and shall conform with all applicable specifications.

3.4.1.1

Methods and equipment employed for placement shall demonstrate the adequacy for use in placement of concrete and shall conform with the requirements specified herein. The quantities of all materials placed within the section shall be accurately tabulated and provided immediately to the Contracting Officer for comparison with the theoretical quantities.

3.4.1.2 Demonstration Section Evaluation

The Contractor shall not proceed with concrete placement prior to the approval of the demonstration section. Within a period of 7 days after completion of the section, the Contracting Officer shall determine the adequacy and acceptability of the section. The Contractor shall be notified as to the acceptability of the section and will be required to modify methods of construction, materials, mix design, and remove the section for noncompliance with specifications.

3.4.1.3 Removal of Demonstration Section

The unacceptable demonstration section shall be the property of the Contractor and removed from site with the requirement of SECTION: ENVIRONMENTAL PROTECTION.

3.5 CURING AND PROTECTION

3.5.1 General

All concrete shall be cured by an approved method for a period of 7 days. Immediately after placement, concrete shall be protected from premature drying, extremes in temperatures, rapid temperature change, and mechanical injury. All materials and equipment needed for adequate curing and protection shall be available and at the placement site prior to the start of concrete placement. Concrete shall be protected from the damaging effects of rain for 12 hours and from flowing water for 14 days (7 days with Type III cement). Concrete shall be shielded from direct rays of the sun for 3 days. No fire or excessive heat shall be permitted near or in direct contact with concrete at any time.

3.5.2 Moist Curing

Concrete moist-cured shall be maintained continuously (not periodically) wet for the entire curing period. If water or curing materials stain or discolor concrete surfaces that are to be permanently exposed, they shall be cleaned as required in paragraph: Appearance. Where wooden form sheathing is left in place during curing, the sheathing shall be kept wet at all times. Horizontal surfaces may be moist cured by ponding, by covering with a minimum uniform thickness of 2 inches of continuously saturated sand, or by covering with saturated nonstaining burlap or cotton mats. Horizontal construction joints may be allowed to dry for 12 hours immediately prior to the placing of the following lift.

3.5.3 Membrane Curing

Concrete may be cured with an approved curing compound in lieu of moist curing except that membrane curing will not be permitted on any surface to which a sack-rubbed finish is to be applied, on any surface containing protruding steel reinforcement, or on abrasive aggregate finish.

3.5.3.1 Pigmented Curing Compound

A pigmented-type curing compound conforming to ASTM C 309 may be used on surfaces that will not be exposed to view when the project is completed. Membrane curing shall not be used on surfaces that are to receive any subsequent treatment depending on adhesion or bonding to the concrete. A nonpigmented-type curing compound, containing a fugitive dye, conforming to ASTM C 309, type 1-D with the reflective requirements waived may be used on surfaces that will be exposed to view when the project is completed.

3.5.3.2 Application

The curing compound shall be applied to formed surfaces immediately after the forms are removed and prior to any patching or other surface treatment except the cleaning of loose sand, mortar, and debris from the surface. The surfaces shall be thoroughly moistened with water, and the curing compound applied as soon as free water disappears. The curing compound shall be applied to unformed surfaces as soon as free water has disappeared. The curing compound shall be applied in a two-coat continuous operation by approved motorized power-spraying equipment operating at a minimum pressure of 75 pounds per square inch, at a uniform coverage of not more than 400 square feet per gallon for each coat, and the second coat shall be applied perpendicular to the first coat. When adverse breeze conditions occur, Contractor shall take the necessary precautions to prevent the curing compound from becoming airborne. These precautions shall include, but not limited to, lowering the spray nozzle to approximately 2 feet away from the concrete surface and erecting wind breaks. The method used shall be submitted to the Contracting Officer for approval. Concrete surfaces that have been subjected to rainfall within 3 hours after curing compound has been applied shall be resprayed by the method and at the coverage herein specified. All concrete surfaces on which the curing compound has been applied shall be adequately protected for the duration of the entire curing period from pedestrian and vehicular traffic and from any other cause that will disrupt the continuity of the curing membrane.

3.5.4 Impervious-Sheet Curing

The concrete invert surfaces may be cured by an approved impervious sheet. All surfaces shall be thoroughly wetted and be completely covered with waterproof paper, polyethylene film, or polyethylene-coated burlap having the burlap thoroughly water-saturated before placing. Covering shall be laid with light-colored side up. Covering shall be lapped not less than 12 inches and securely weighted down or shall be lapped not less than 4 inches and taped to form a continuous cover with completely closed joints. The sheet shall be weighted to prevent displacement so that it remains in contact with the concrete during the specified length of curing. Coverings shall be folded down over exposed edges of slabs and secured by approved means. Sheets shall be immediately repaired or replaced if tears or holes appear during the curing period.

3.5.5 Cold Weather

When the daily outdoor low temperature is less than 32 degrees F, the temperature of the concrete shall be maintained above 40 degrees F for the first 7 days after placing. In addition, during the period of protection removal, the air temperature adjacent to the concrete surfaces shall be controlled so that concrete near the surface will not be subjected to a temperature differential of more than 25 degrees F as determined by observation of ambient and concrete temperatures indicated by suitable thermometers installed adjacent to the concrete surface and 2 inches inside the surface of the concrete. The installation of the thermometers shall be made by the Contractor at such locations as may be directed. Curing compounds shall not be used on concrete surfaces that are maintained at curing temperature by use of free steam.

3.6 CONTRACTOR QUALITY CONTROL

3.6.1 General

The Contractor shall perform the inspection and tests described in paragraph: Inspection Details and Frequency of Testing, and based upon the results of these inspections and tests, he shall take the action required in paragraph: Action Required and submit reports as required in paragraphs: Action Required and Reports. The laboratory performing the tests shall conform with ASTM C 1077. The individuals who sample and test concrete or the constituents of concrete as required in this specification shall have demonstrated a knowledge and ability to perform the necessary test procedures equivalent to the ACI minimum guidelines for certification of Concrete Field Testing Technicians, Grade I.

3.6.2 Inspection Details and Frequency of Testing

3.6.2.1 Fine Aggregate

3.6.2.1.1 Grading

At least once during each shift in which concrete is being delivered, there shall be one sieve analysis and fineness modulus determination in accordance with ASTM C 136 and COE CRD-C 104, respectively, for the fine aggregate or for each fine aggregate, if it is batched in more than one size or classification. The location at which samples are taken may be selected by the Contractor as the most advantageous for control. However, the Contractor is responsible for delivering fine aggregate to the mixer within specification limits. Results of tests shall be reported in writing.

3.6.2.1.2 Moisture Content

When in the opinion of the Contracting Officer the electric moisture meter is not operating satisfactorily, there shall be at least four tests for moisture content in accordance with either ASTM C 70, C 566, or COE CRD-C 112 during each 8-hour period of mixing plant operation. The times for the tests shall be selected randomly within the 8-hour period. An additional test shall be made whenever the slump is shown to be out of control or excessive variation in workability is reported by the placing foreman. When the electric moisture meter is operating

satisfactorily, at least two direct measurements of moisture content shall be made per week to check the calibration of the meter.

3.6.2.2 Coarse Aggregate

3.6.2.2.1 Grading

At least once during each shift that concrete is being delivered, there shall be a sieve analysis in accordance with ASTM C 136 for each size group of coarse aggregate. The location at which samples are taken may be selected by the Contractor as the most advantageous for production control. However, the Contractor is responsible for delivering the aggregate to the mixer within specification limits. A test record of samples of aggregate taken shall show the results of the five most recent tests including the current test. The Contractor may adopt limits for control coarser than the specification limits for samples taken other than at the batch plant bins to allow for degradation during handling. Results of tests shall be reported in writing.

3.6.2.2.2 Moisture Content

A test for moisture content of each size of coarse aggregate in accordance with ASTM C 566 or COE CRD-C 112 shall be made at least once a shift. When two consecutive readings for smallest size coarse aggregate differ by more than 0.5 percent, frequency of testing shall be increased to that specified for fine aggregate in paragraph: Moisture Content. These results shall be used to adjust the added water in the control of the batch plant.

3.6.2.3 Deleterious Substances

When in the opinion of the Contracting Officer a problem exists in connection with deleterious substances in fine or coarse aggregates, tests shall be made in accordance with ASTM C 33 at a frequency not less than one per week. Results of tests shall be reported in writing.

3.6.2.4 Scales

3.6.2.4.1 Weighing Accuracy

The accuracy of the scales shall be checked by test weights at least once a month for conformance with the applicable requirement of paragraph: Scales. Such tests shall also be made whenever there are variations in properties of the fresh concrete that could result from batching errors. Results of tests shall be reported in writing.

3.6.2.4.2 Batching and Recording Accuracy

Once a week the accuracy of each batching and recording device shall be checked during a weighing operation by noting and recording the required weight, recorded weight, and the actual weight batched. The Contractor shall provide the necessary calibration devices and confirm that the admixture dispensers described in paragraph: Equipment, are operating properly. Results of tests shall be reported in writing.

3.6.2.5 Batch-Plant Control

The measurement of all constituent materials including cement, pozzolan, each size of aggregate, water, and admixtures shall be continuously controlled. The aggregate weights and amount of added water shall be adjusted as necessary to compensate for free moisture in the aggregates. The amount of air-entraining admixture shall be adjusted to control air content within specified limits. A report shall be prepared indicating type and source of cement used, type and source of pozzolan used, amount and source of admixtures used, aggregate source, the required aggregate and water weights per cubic yard, amount of water as free moisture in each size of aggregate, and the batched aggregate and water weights per cubic yard for each class of concrete batched during plant operation. The report shall be submitted to the Contracting Officer.

3.6.2.6 Concrete

3.6.2.6.1 Air Content

At least two tests for air content shall be made on randomly selected batches of each class of concrete during each 8-hour period of concrete production. Additional tests shall be made when excessive variation in workability is reported by the placing foreman or the Contracting Officer. Tests shall be made in accordance with ASTM C 231. For concrete having a nominal maximum aggregate size of 3/4 to 1-1/2 inches, the average of each set of two tests shall be plotted on a control chart on which the average is set at 5 percent and the upper and lower control limits at 4 and 6 percent, respectively. The control charts shall be submitted to the Contracting Officer.

3.6.2.6.2 Slump

At least two slump tests shall be made on randomly selected batches of each mixture of concrete during each day's concrete production in accordance with ASTM C 143. Additional tests shall be made when excessive variation in workability is reported by the placing foreman or the Contracting Officer. The average of each set of two tests shall be plotted on a control chart on which the upper and lower limits are set 1.5 inches above and below the mid-range value. The range shall be plotted on a control chart on which the upper control limit is 3.0 inches. The control chart shall be submitted to the Contracting Officer.

3.6.2.6.3 Batch Tickets

The manufacturer of the concrete shall furnish to the Contracting Officer's Representative with each batch of concrete, before unloading at the site, a delivery ticket prepared in accordance with the requirements of ASTM C 94.

3.6.2.7 Preparation for Placing

Foundation or construction joints, forms, and embedded items shall be inspected in sufficient time prior to each concrete placement by the Contractor in order to certify to the Contracting Officer that they are ready to receive concrete. The results of each inspection shall be reported in writing.

3.6.2.8 Placing

The placing foreman shall supervise all placing operations, shall determine that the correct quality of concrete or grout is placed in each location as directed by the Contracting Officer, and shall be responsible for measuring and recording concrete temperatures, ambient temperature, weather conditions, time of placement, yardage placed, and method of placement. A report shall be submitted in writing to the Contracting Officer.

3.6.2.9 Vibrators

The frequency and amplitude of each vibrator shall be determined in accordance with COE CRD-C 521 prior to initial use and at least once a month when concrete is being placed. Additional tests shall be made when a vibrator does not appear to be adequately consolidating the concrete. The frequency shall be determined while the vibrator is operating in concrete with the tachometer being held against the upper end of the vibrator while almost submerged and just before the vibrator is withdrawn from the concrete. The amplitude shall be determined with the head vibrating in air. Two measurements shall be taken, one near the tip and another near the upper end of the vibrator head, and these results averaged. The make, model, type, and size of the vibrator and frequency and amplitude results shall be reported in writing.

3.6.2.10 Curing

3.6.2.10.1 Moist Curing

At least once each day during the curing period, an inspection shall be made of all areas subject to moist curing. The surface moisture condition shall be reported in writing.

3.6.2.10.2 Curing Compound

No curing compound shall be applied until it has been verified that the compound is properly mixed and ready for spraying. At the end of each operation, the quantity of compound used and the area of concrete surface covered shall be reported, and the rate of coverage in square feet per gallon shall be computed. The report shall state whether coverage is uniform.

3.6.2.10.3 Impervious-Sheet Curing

At least once each day during the curing period, an inspection shall be made of all areas being cured using impervious sheets. The condition of the covering and the tightness of the laps and tapes shall be noted and recorded.

3.6.2.11 Protection

At least once a day during the curing period, an inspection shall be made of all areas subject to cold-weather protection. Deficiencies shall be noted. During removal of protection, measurement of concrete and ambient temperature shall be made at least hourly. A report shall be submitted in writing to the Contracting Officer.

3.6.2.12 Mixer Uniformity

3.6.2.12.1 Concrete Plant Mixer

At the start of concrete placing, and at least once every 3 months when concrete is being placed, uniformity of concrete shall be determined. The tests shall be performed in accordance with ASTM C 94. Whenever adjustments in mixer or increased mixing times are necessary because of failure of any mixer to comply, the mixer shall be retested after adjustment. Results of tests shall be reported in writing.

3.6.2.12.2 Truck Mixers

At the start of concrete placing and at least once every 6 months when concrete is being placed, uniformity of concrete shall be determined in accordance with ASTM C 94. The truck mixers shall be selected randomly for testing. When satisfactory performance is found in one truck mixer, the performance of mixers of substantially the same design and condition of blades may be regarded as satisfactory. Results of tests shall be reported in writing.

3.6.2.13 Action Required

3.6.2.13.1 Fine Aggregate

3.6.2.13.1.1 Grading

When the amount passing any sieve is outside the specification limits, the fine aggregate shall be immediately resampled and retested. If there is another failure on any sieve, the fact shall immediately be reported to the Contracting Officer, and immediate steps shall be taken to rectify the situation.

3.6.2.13.1.2 Moisture

Whenever the moisture content of the fine aggregate changes by 0.5 percent or more, the scale settings for the fine-aggregate batcher and water batcher shall be adjusted directly or by means of a moisture compensation device.

3.6.2.13.2 Coarse Aggregate Grading

When the amount passing any sieve is outside the specification limits, the coarse aggregate shall immediately be resampled and retested. If the second sample fails on any sieve, that fact shall be reported to the Contracting Officer. Where two consecutive averages of five tests are outside specification limits, that fact shall be reported to the Contracting Officer, and immediate steps shall be taken to correct the grading.

3.6.2.13.3 Deleterious Substances

When the results for a deleterious substance are outside the specification limit, the aggregate shall be resampled and retested for the deleterious substance that failed. If the second sample fails, that fact shall be reported to the Contracting Officer. When material finer than No. 200 sieve for coarse aggregate exceeds the specification limit, immediate steps, such as washing or other corrective actions, shall be initiated.

3.6.2.13.4 Scales

Whenever either the weighing accuracy or batching accuracy is found not to comply with specification requirements, the plant shall not be operated until necessary adjustments or repairs have been made. Discrepancies in recording accuracies shall be corrected immediately.

3.6.2.13.5 Concrete

3.6.2.13.5.1 Air Content

Whenever points on the control chart approach the upper or lower control limits, an adjustment should be made in the amount of air-entraining admixture batched. If a single test result is outside the specification limit, such adjustment is mandatory. As soon as practical after each adjustment, another test shall be made to verify the correctness of the adjustment. Whenever a point falls above the upper control limit for range, the dispenser shall be calibrated to ensure that it is operating correctly and with good reproducibility. Whenever two consecutive points for either average or range are outside the control limits, the Contracting Officer shall be notified. Whenever the air content departs from the specified range, the concrete shall not be delivered to the forms.

3.6.2.13.5.2 Slump

Whenever points on the control chart approach the upper or lower control limits, an adjustment should be made in the batch weights of water and fine aggregate. The adjustments are to be made so that the total free water does not exceed that amount specified in the approved mixture proportions based on the free water available with the fine aggregate and that amount of water batched. If the adjustments to the batch weights or water and fine aggregate do not satisfactorily produce the required slump, the mixture shall be reproportioned to meet the specified criteria and resubmitted to the Contracting Officer for approval. When a single slump is outside the control limits, such adjustment is mandatory. As soon as practical after each adjustment, another test shall be made to verify the correctness of the adjustment. Whenever the slump exceeds the upper limit stipulated in paragraph: Mixture Proportioning, subparagraph Slump, the concrete shall not be delivered to the forms. Whenever two consecutive slump tests, made during a period when there was no adjustment of batch weights, produce a point on the control chart for range above the upper control limit, the slump shall be considered to be out of control, and the additional testing for aggregate moisture content required in paragraph: Inspection Details and Frequency of Testing shall be undertaken.

3.6.2.13.5.3 Strength

Tests shall be performed in accordance with ASTM C 94 to ensure that specified concrete strengths are obtained. Results of tests shall be reported in writing.

3.6.2.13.6 Placing

The placing foreman shall not permit placing to begin until he has verified that an adequate number of acceptable vibrators in working order and with competent operators are available. Placing shall not be continued if any pile of concrete

is inadequately consolidated. If any batch of concrete fails to meet the temperature requirements, immediate steps shall be taken to improve temperature controls.

3.6.2.13.7 Curing

3.6.2.13.7.1 Moist Curing

When a daily inspection report lists an area of inadequate curing, the required curing period for that area shall be extended by 1 day.

3.6.2.13.7.2 Curing Compound

When the coverage rate of curing compound is less than that specified or when the coverage is not uniform, the entire surface shall be sprayed again.

3.6.2.13.7.3 Impervious-Sheet Curing

When a daily inspection report lists any tears, holes, or laps of joints that are not completely closed, the tears and holes shall promptly be repaired or the sheets replaced, the joints closed, and the required curing period for those areas shall be extended by 1 day.

3.6.2.13.8 Protection

When any concrete temperature during the period of protection or protection removal fails to comply with the specifications, that fact shall be reported to the Contracting Officer, and immediate steps should be taken to correct the situation.

3.6.2.13.9 Mixer Uniformity

When a mixer fails to meet mixer uniformity requirements, either the mixing time shall be increased or adjustments shall be made to the mixer until compliance is achieved.

3.6.2.14 Reports

All results of tests shall be reported as required. Each report shall include the updating of control charts covering the entire period from the start of the construction season through the current week. During periods of cold-weather protection, reports of pertinent temperatures shall be made daily. These requirements do not relieve the Contractor of the obligation to report certain failures immediately as required in preceding paragraphs. Such reports of failures and the action taken shall be confirmed in writing in the routine reports. All concrete reports, including compressive strength, concrete temperatures, ambient temperatures, slump, air content, mix design number, test number and location of concrete placement shall be submitted in a spreadsheet format and on computer disk(s) to the Contracting Officer. The Contracting Officer has the right to examine all Contractor quality control records.

3.7 TOLERANCES FOR CRACK WIDTHS

3.7.1 Tolerable Crack Width

Tolerable crack width shall be 0.012 inches. Any cracks wider than the tolerable shall be sealed by pressure epoxy injection (ASTM C881) or other method approved by the Contracting Officer.

-- End of Section --

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CONCRETE

SECTION 03340

CONCRETE SIDEWALKS, CURBS, GUTTERS AND DRIVEWAY ENTRANCES

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SECTION 03340

CONCRETE SIDEWALKS, CURBS, GUTTERS AND DRIVEWAY ENTRANCES

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 182(1991I)	Burlap Cloth made from Jute or Kenaf

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 94	(1992a) Ready-Mixed Concrete
ASTM C 171	(1992) Sheet Materials for Curing Concrete
ASTM C 309	(1993) Liquid Membrane-Forming Compounds for Curing Concrete
ASTM D 1751	(1983; R 1991) Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D 1752	(1984; R 1992) Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D 1850	(1974; R 1979) Concrete Joint Sealer, Cold-Application Type

FEDERAL SPECIFICATION (FS)

FS SS-S-1401	(Rev C; Am 1; Notice 1) Sealant, Joint, Non-Jet-Fuel-Resistant, Hot-Applied, for Portland Cement and Asphalt Concrete Pavements

1.2 FIELD-CONTROL TESTS

Preparation of field-control samples and testing of samples shall be by the Contractor at no additional cost to the Government. The taking of samples, the making of test specimens, and the testing thereof shall be performed under the supervision of the Contracting Officer.

1.3 MATERIALS

Materials shall conform to the respective publications and other requirements specified herein.

1.3.1 Concrete Curing Materials

1.3.1.1 Burlap

AASHTO M 182 having a weight of 14 ounces or more per square yard when dry, and shall be non-staining.

1.3.1.2 Impervious Sheeting

ASTM C 171.

1.3.1.3 Liquid Membrane Curing Compound

ASTM C 309 Type 2. Compound shall be free of paraffin or petroleum.

1.3.2 Concrete Protection Materials

Linseed oil mixture shall be equal parts, by volume, of linseed oil and either mineral spirits, naphtha, or turpentine. At the option of the Contractor, commercially prepared linseed oil mixtures formulated specifically for application to concrete to provide protection against the action of deicing chemicals may be used except that emulsified mixtures are not acceptable.

1.3.3 Joint Materials

1.3.3.1 Expansion Joint Fillers

ASTM D 1751 or ASTM D 1752 or shall be resin impregnated fiberboard conforming to the physical requirements of ASTM D 1752.

1.3.3.2 Joint Sealers

ASTM D 1850 or FS SS-S-1401.

1.4 CONCRETE STRENGTH AND USAGE

1.4.1 Concrete

Concrete and materials therefore shall conform to the applicable requirements of SECTION: CAST-IN-PLACE STRUCTURAL CONCRETE and ASTM C 94, Alternative No. 2 except as specified below. Concrete shall have a minimum compressive strength of 2,500 psi. The maximum size of aggregate shall be one inch. Concrete shall have a slump of not more than 3 inches.

1.5 FORMS

1.5.1 Sidewalk

Sidewalk forms shall be of wood or steel, straight, of sufficient strength to resist springing during depositing and consolidating concrete, and of a height equal to the full depth of the finished sidewalk. Wood forms shall be surfaced plank, 2-inch nominal thickness, straight and free from warp, twist, loose knots, splits or other defects. Wood forms shall have a nominal length of 10 feet, with a minimum of three

stakes per form, at maximum spacing of 4 feet. Corners, deep sections, and radius bends shall have additional stakes and braces, as required. Radius bends may be formed with 3/4-inch boards, laminated to the required thickness. Steel forms shall be channel-formed sections with a flat top surface and with welded braces at each end and at not less than two intermediate points. Form ends shall be interlocked and self-aligning. Forms shall include flexible forms for radius forming, corner forms, form spreaders, and fillers. Forms shall have a nominal length of 10 feet, with a minimum of two welded stake pockets per form. Stake pins shall be solid steel rods with chamfered heads and pointed tips, designed for use with steel forms.

1.5.2 Curb, Gutter, and Driveway Entrance

Curb and gutter forms shall be of wood or steel, straight, and of sufficient strength to resist springing during depositing and consolidating the concrete. The outside forms shall have a height equal to the full depth of the curb or gutter. The inside form of curb shall have batter as indicated and shall be securely fastened to and supported by the outside form. Straight forms of wood shall be surfaced plank, 2-inch nominal thickness, straight and free from warp, twist, loose knots, splits, or other defects. Wood forms shall have a nominal length of 10 feet, with a minimum of three stakes per form, at maximum spacing of 4 feet. Corners, deep sections, and radius bends shall have additional stakes and braces, as required. Radius bends may be formed with 3/4-inch boards, laminated to the required thickness. Steel forms shall be channel-formed sections with a flat top surface and with welded braces at each end and at not less than two intermediate points. Form ends shall be interlocked and self-aligning. Forms shall include flexible forms for radius forming, corner forms, form spreaders, and fillers. Forms shall have a nominal length of 10 feet, with a minimum of two welded stake pockets per form. Stake pins shall be solid steel rods with chamfered heads and pointed tips, designed for use with steel forms. Rigid forms shall be provided for curb returns, except that benders of thin plank forms may be used for curb or curb returns with a radius of 10 feet or more, where grade changes occur in the return, or where the central angle is such that a rigid form with a central angle of 90 degrees cannot be used. Back forms for curb returns may be made of 1-1/2 inch benders, for the full height of the curb, cleated together.

1.6 SUBGRADE PREPARATION

The subgrade shall be constructed to grade and cross section.

1.6.1 Sidewalk Subgrade

The subgrade shall be thoroughly wetted and then compacted with two passes of a 500-pound roller. Yielding material deflecting more than 1/2 inch under the specified roller shall be removed to a depth of not less than 4 inches below subgrade elevation and replaced with an approved granular material. The material shall then be compacted as described above. The completed subgrade shall be tested for grade and cross section with a template extending the full width of the sidewalk and supported between side forms.

1.6.2 Curb, Gutter, and Driveway Entrance Subgrade

The subgrade shall be of materials equal in bearing quality to the subgrade under the adjacent pavement and shall be placed and compacted to conform with applicable requirements of SECTION: FILLS AND SUBGRADE PREPARATION. The subgrade shall be

tested for grade and cross section by means of a template extending the full width of the curb and gutter.

1.6.3 Maintenance of Subgrade

The subgrade shall be maintained in a smooth, compacted condition, in conformity with the required section and established grade until the concrete is placed. The subgrade shall be in a moist condition when concrete is placed. The subgrade shall be prepared and protected so as to produce a subgrade free from frost when the concrete is deposited.

1.7 FORM SETTING

1.7.1 Sidewalk

Forms for sidewalks shall be set with the upper edge true to line and grade and shall be held rigidly in place by stakes placed at intervals not to exceed 4 feet. After forms are set, grade and alignment shall be checked with a 10-foot straightedge. Forms shall conform to line and grade with an allowable tolerance of 1/8 inch in any 10-foot long section. Forms shall have a transverse slope of 1/4 inch per foot with the low side adjacent to the roadway. Forms shall be coated with form oil each time before concrete is placed. Wood forms may, instead, be thoroughly wetted with water before concrete is placed, except that with probable freezing temperatures, oiling is mandatory. Side forms shall not be removed for less than 12 hours after finishing has been completed.

1.7.2 Curbs and Driveway Entrances

Forms for curbs and driveway entrances shall be set to alignment and grade and to conform to the dimensions of the curb and driveway entrances. Forms shall be held rigidly in place by the use of stakes placed at intervals not to exceed 4 feet. Clamps, spreaders, and braces shall be used where required to insure rigidity in the forms. The forms on the front of the curb shall be removed not less than 2 hours nor more than 6 hours after the concrete has been placed. Forms back of curb shall remain in place until the face and top of the curb have been finished as specified for concrete finishing. Gutter forms shall not be removed while the concrete is sufficiently plastic to slump in any direction. Forms shall be cleaned and coated with form oil each time before concrete is placed. Wood forms may, instead, be thoroughly wetted with water before concrete is placed, except that with probable freezing temperatures, oiling is mandatory.

1.8 CONCRETE PLACEMENT AND FINISHING

1.8.1 Sidewalk Concrete

Concrete shall be placed in the forms in one layer of such thickness that when compacted and finished the sidewalk will be of the thickness indicated. After concrete has been placed in the forms, a strike-off guided by side forms shall be used to bring the surface to proper section to be compacted. The concrete shall be tamped and consolidated with a suitable wood or metal tamping bar, and the surface shall be finished to grade with a wood float. Finished surface of the walk shall not vary more than 3/16 inch from the testing edge of a 10 foot-straightedge. Irregularities

exceeding the above shall be corrected. The surface shall be divided into rectangular areas by means of contraction joints spaced at not more than 5 feet on centers.

1.8.1.1 Concrete Finishing

After straightedging, when most of the water sheen has disappeared, and just before the concrete hardens, the surface shall be finished to a smooth and uniformly fine granular or sandy texture free of waves, irregularities, or tool marks. A scored surface shall be produced by brooming with a fiber-bristle brush in a direction transverse to that of the traffic. Contractor shall submit installation procedures for concrete to the Contracting Officer for approval. All sidewalk and bike path surfaces shall be given a rough texture by brooming with a fiber-bristle broom in a direction transverse to that of the main traffic flow. The rough texture finish shall also be applied to adjacent surfaces a sufficient distance in all directions to provide adequate texture for traction in turning areas.

1.8.1.2 Edge and Joint Finishing

All slab edges, including those at formed joints, shall be finished carefully with an edger having a radius of 1/8 inch. Transverse joints shall be edged before brooming, and the brooming shall eliminate the flat surface left by the surface face of the edger. Corner and edges which have crumbled and areas which lack sufficient mortar for proper finishing shall be cleaned and filled solidly with a properly proportioned mortar mixture and then finished.

1.8.1.3 Contraction Joints

The contraction joints shall be formed in the fresh concrete by cutting a groove in the top portion of the slab to a depth of at least one-fourth of the sidewalk slab thickness, using a jointer to cut the groove, or by sawing a groove in the hardened concrete with a power-driven saw, unless otherwise approved. Sawed joints shall be constructed by sawing a groove in the concrete with a 1/8-inch blade to the depth indicated. The time of sawing shall be varied, depending on existing and anticipated weather conditions, and such sawing shall be at the required rate. An ample supply of saw blades shall be available on the job before concrete placement is started, and at least one standby sawing unit in good working order shall be available at the jobsite at all times during the sawing operations.

1.8.1.4 Expansion Joints

Transverse expansion joints shall be installed at sidewalk returns and opposite expansion joints in adjoining curbs. Where the sidewalk is not in contact with the curb, transverse expansion joints shall be installed as indicated. Transverse expansion joints shall be filled with 1/2-inch joint filler strips. Joint filler shall be placed with top edge 1/4 inch below the surface and shall be held in place with steel pins or other devices to prevent warping of the filler during floating and finishing. Immediately after finishing operations are completed, joint edges shall be rounded with an edging tool having a radius of 1/8 inch, and concrete over the joint filler shall be removed. Expansion joints shall be formed about structures and features that project through or into the sidewalk pavement, using joint filler of the type, thickness, and width indicated. The filler shall be installed in such manner as to form a complete, uniform separation between the structure and sidewalk pavement. At the end of the curing period, expansion joints shall be cleaned and filled with

joint sealer. Concrete at the joint shall be surface dry, and the atmospheric and pavement temperatures shall be above 50 degrees F. at the time of application of joint-sealing materials. Joints shall be filled flush with the concrete surface in such manner as to minimize spilling on the walk surface. Spilled sealing material shall be removed immediately and the surface of the walk cleaned. Dummy groove joints shall not be sealed.

1.8.1.5 Surface Uniformity

The completed surface shall be uniform in color and free of surface blemishes and tool marks.

1.8.2 Curb, Gutter, and Driveway Entrance Concrete

Concrete shall be placed in layers not to exceed 6 inches. Concrete shall be thoroughly consolidated by tamping and spading or with approved mechanical vibrators.

1.8.2.1 Concrete Finishing

The edges of the gutter and top of the curb shall be rounded with an edging tool to a radius of 1/2-inch and the surfaces shall be floated and finished with a smooth wood float until true to grade and section and uniform in texture. Floated surfaces shall then be brushed with a fine-hair brush with longitudinal strokes. Immediately after removing the front curb form, the face of the curb shall be rubbed with a wood or concrete rubbing block and water until blemishes, form marks, and tool marks have been removed. The surface, while still wet, shall be brushed in the same manner as the gutter and curb top. The top surface of gutter and entrance shall be finished to grade with a wood float. Except at grade changes or curves, finished surfaces shall not vary, from the testing edge of 10-foot straightedge, more than 1/8 inch for gutter and entrance and 1/4 inch for top and face of curb. Irregularities exceeding the above shall be satisfactorily corrected. Visible surfaces and edges of finished curb and gutter shall be free of blemishes and form and tool marks, and shall be uniform in color, shape, and appearance.

1.8.2.2 Joints

Expansion joints and contraction joints shall be constructed at right angles to the line of curb and gutter.

1.8.2.2.1 Contraction Joints

Contraction joints shall be constructed by means of 1/8-inch thick separators, of a section conforming to the cross section of the curb and gutter. Contraction joints shall be constructed directly opposite contraction joints in abutting portland-cement-concrete pavement. Where curb and gutter do not abut portland-cement-concrete pavements, contraction joints shall be so placed that monolithic sections between curb returns will not be less than 5 feet nor greater than 15 feet in length. Separators shall be removed as soon as practicable after concrete has set sufficiently to preserve the width and shape of the joint. Separators shall be removed prior to finishing.

1.8.2.2.2 Expansion Joints

Expansion joints shall be formed by means of preformed expansion-joint filler material cut and shaped to the cross section of curb and gutter. Expansion joints shall be provided in curb at the end of all returns. Expansion joints shall be provided in curb and gutter directly opposite expansion joints of abutting portland-cement-concrete pavement and shall be of the same type and thickness as joints in the pavement. Where curb and gutter do not abut portland-cement-concrete pavement, expansion joints at least 1/2-inch in width shall be provided at intervals not exceeding 25 feet. Expansion joints shall be provided in non-reinforced concrete gutter at locations indicated.

1.9 CURING AND PROTECTION

1.9.1 Curing

Immediately after the finishing operations, exposed concrete surfaces shall be cured by one of the following methods as the Contractor may elect.

1.9.1.1 Mat Method

The entire exposed surface shall be covered with two or more layers of burlap. Mats shall overlap each other at least 6 inches. The mat shall be thoroughly wetted with water prior to placing on concrete surface and shall be kept continuously in a saturated condition and in intimate contact with concrete for not less than 7 days.

1.9.1.2 Impervious Sheeting Method

The entire exposed surface shall be wetted with a fine spray of water and then covered with impervious sheeting material. Sheets shall be laid directly on the concrete surface with the light-colored side up and overlapped 12 inches when a continuous sheet is not used. The curing medium shall not be less than 18 inches wider than the concrete surface to be cured, and shall be securely weighted down by heavy wood planks, or by placing a bank of moist earth along edges and laps in the sheets. Sheets shall be satisfactorily repaired or replaced if torn or otherwise damaged during curing. The curing medium shall remain on the concrete surface to be cured for not less than 7 days.

1.9.1.3 Membrane-Curing Method

The entire exposed surface shall be covered with a membrane-forming curing compound. Where type 1 curing compound is used, the concrete surface shall be shaded from the direct rays of the sun during the curing period. Curing compound shall be applied in two coats by hand-operated pressure sprayers at a coverage of approximately 200 square feet per gallon for both coats. The second coat shall be applied in a direction approximately at right angles to the direction of application of the first coat. The compound shall form a uniform, continuous, coherent film that will not check, crack, or peel and shall be free from pinholes or other imperfections. Apply an additional coat to all surfaces showing discontinuity, pinholes or other defects. Concrete surfaces that are subjected to heavy rainfall within 3 hours after curing compound has been applied shall be resprayed by the above method and at the above coverage at no additional cost to the Government. Expansion-joint openings shall be sealed at the top by inserting moistened paper or fiber rope or covering with strips of waterproof paper prior to application of the curing compound, in a manner to prevent the curing compound entering the joint. Concrete surfaces to which membrane-curing compounds

have been applied shall be adequately protected for 7 days from pedestrian and vehicular traffic and from any other action that might disrupt the continuity of the membrane. Any area covered with curing compound and damaged by subsequent construction operations within the 7-day curing period shall be resprayed as specified above at no additional expense to the Government. Color concrete shall be cured as specified in SECTION: CAST-IN-PLACE STRUCTURAL CONCRETE.

1.9.2 Backfilling

After curing, debris shall be removed, and the area adjoining the concrete shall be backfilled, graded, and compacted to conform to the surrounding area in accordance with lines and grades indicated.

1.9.3 Protection

Completed concrete shall be protected from damage until accepted. The Contractor shall clean concrete discolored during construction. Concrete that is damaged shall be removed and reconstructed for the entire length between regularly scheduled joints. Refinishing the damaged portion will not be acceptable. Removed damaged portions shall be disposed of as directed.

1.10 SEALING JOINTS

The approximately horizontal sections of expansion joints and the top one-inch depth of contraction-joint openings of gutter shall be sealed with joint sealer. The joint opening shall be thoroughly cleaned before the sealing material is placed. Sealing shall be done so that the material will not be spilled on exposed surfaces of the concrete. Concrete at the joint shall be surface dry and atmospheric and concrete temperatures shall be above 50 degrees F. at the time of application of joint-sealing materials. Excess material on exposed surfaces of the concrete shall be removed immediately and exposed concrete surfaces cleaned.

PART 2 PRODUCTS (Not Applicable)

PART 3 EXECUTION (Not Applicable)

-- End of Section --